R-2000

SUPER ENERGY EFFICIENT HOME PROGRAM

TECHNICAL REPORT

Canada

1987 ENERGY PERFORMANCE OF R-2000 HOMES UPDATE

034 - MR

An Analysis of Measured Energy Consumption in R-2000 Homes and Updated Comparisons with the R-2000 Target and Computer Predictions for Homes Built to Current Building Practice

Prepared for

The R-2000 Home Program
Energy Efficiency Technology Division
Energy, Mines and Resources Canada

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THE R-2000 HOME PROGRAM TECHNICAL REPORT SERIES

The R-2000 Home Program assists in the ongoing development of the various technologies required to build and operate R-2000 homes. This includes support for standards development and the provision of technical information and resources to the building industry. In addition, R-2000 homes and a control group of conventional homes are being monitored over a two to five year period to gather information on construction techniques, the performance of heating and ventilating systems, indoor air quality and energy consumption. The demographic profile and attitudes of R-2000 homeowners are also being surveyed.

This publication is one of a series of reports documenting technical developments and monitoring activities supported by the R-2000 Home Program and the Canadian housing industry. The program's objective is to assist the housing industry to develop the capability to construct and market quality housing that is both energy-efficient and cost-effective.

For further information on the R-2000 Home Program in general, the series of technical reports, or to obtain additional copies of this report, please contact:

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EXECUTIVE SUMMARY

This report presents the results of energy consumption monitoring from 1985 to 1987 in a sample of R-2000 homes. The objectives are to examine different factors affecting energy consumption in R-2000 homes, to determine if R-2000 homes are performing to R-2000 energy targets, and to compare R-2000 home consumptions with predicted consumptions if built to the 1975 National Building Code and the 1983 Measures for Energy Conservation standards. Space heating, total energy, domestic hot water and lights and appliances consumption are analyzed separately and further subdivided by space heating fuel type and different home characteristics such as volume.

On average, space heating energy consumption was 4% less than the program targets. Total energy consumption was 2% greater than the prediction. Water heating consumption was 11% below the target. Consumption for lights and appliances use was 40% greater than the assumptions used in the HOT-2000 energy analysis program. The R-2000 Program uses a combined space heating and domestic hot water purchased energy target, so R-2000 homes are performing well within the program target.

R-2000 home space heating consumption was equal to 29% of the consumption predicted for homes built to the 1975 National Building Code requirements and 62% of the consumption predicted for homes built to those of the 1983 Measures for Energy Conservation. This corresponds to energy savings of 93.5 GigaJoules (GJ) and 23.4 GJ per heating season per house, respectively. Total energy consumption was equal to 48% of the consumption predicted for homes built to the 1975 National Building Code requirements and 77% of the consumption predicted for homes built to those of the 1983 Measures for Energy Conservation. This represents annual energy savings per home of 91.2 GJ and 25.8 GJ respectively. Actual lights and appliances consumption was greater than assumed, which reduced the total energy savings predicted.

Average space heating consumption was 65.4 MegaJoules per cubic meter (MJ/m^3) per heating season in electrically heated homes and 97.4 MJ/m^3 in homes heated with fossil fuels. Average total energy consumed was 152.5 MJ/m^3 per year in homes with electric space heating, and 198.8 MJ/m^3 per year in homes with fossil fuel space heating. Electric domestic hot water consumption was 16.4 GJ per year or 12.5 kWh/day, and fossil fuel water heating consumption was 30.0 GJ per year or 22.8 kWh/day. Lights and appliances consumption averaged 29.5 GJ per year or 22.4 kWh/day.

Climate, volume and indoor air temperature were the factors that had the greatest impact on both space heating and total energy consumption. Climate was the strongest factor affecting hot water consumption, while both occupancy and climate had a significant impact on consumption for lights and appliances.

RÉSUMÉ POUR LA DIRECTION

Le présent rapport contient les résultats d'une surveillance de la consommation énergétique de maisons R-2000 effectué de 1985 à 1987. Les objectifs consistent à examiner divers facteurs influant sur la consommation en énergie des maisons R-2000, à déterminer si les maisons R-2000 ont atteint les objectifs de rendement énergétique établis, et à comparer la consommation de maison R-2000 et la consommation prévue des maisons construites conformément aux Code national du bâtiment de 1975 et aux normes élaborées dans le cadre des mesures d'économie d'énergie de 1983. La consommation d'énergie totale, la consommation pour le chauffage des pièces, le chauffage de l'eau domestique, l'éclairage et les appareils ménagers est analysée séparément, puis subdivisée en fonction du type de combustible utilisé pour le chauffage des pièces et différentes caractéristiques de la maison, notamment le volume.

En moyenne, la consommation de l'énergie pour le chauffage des pièces était inférieure de 4% au taux visé par le programme. La consommation énergétique totale était supérieure de 2% aux prévisions. La consommation d'énergie pour le chauffage de l'eau était inférieure de 11% au niveau visé. L'utilisation de l'énergie pour l'éclairage et les appareils ménagers était supérieure de 40% aux prévisions du programme d'analyse énergétique HOT-2000. Puisque le Programme de la maison R-2000 s'est fixé un objectif combiné en fait d'énergie achetée pour le chauffage des pièces et le chauffage de l'eau domestique, le rendement des maisons R-2000 correspond largement à l'objectif établi par le programme.

La consommation d'énergie pour le chauffage des pièces des maisons R-2000 était équivalente à 29% de la consommation prévue pour les maisons construites suivant le Code national du bâtiment de 1975 et à 62% de la consommation prévue pour les maisons construites conformément aux mesures d'économie d'énergie de 1983. Il s'agit donc d'économies d'énergie respectives de 93,5 GigaJoules (GJ) et de 23,4 GJ par saison de chauffage par maison. La consommation énergétique totale était équivalente à 48% de la consommation prévue pour les maisons construites selon le Code national du bâtiment de 1975 et à 77% de la consommation prévue pour les maisons construites suivant les mesures d'économie d'énergie de 1983. Cela représente respectivement des économies d'énergies annuelles par maison de 91,2 GJ et de 25,8 GJ. La consommation réelle pour l'éclairage et les appareils ménagers a été plus importante que la consommation présumée ce qui a réduit les économies d'énergie totales prévues.

La consommation d'énergie moyenne pour le chauffage des pièces était de 65,4 MégaJoules par mètre cubique (MJ/m^3) par saison de chauffage dans les maisons chauffées à l'électricité, et de 97,4 MJ/m^3 dans les maisons chauffées au moyen de combustibles fossiles. La consommation d'énergie totale était de 152,5 MJ/m^3 par année dans le cas des maisons chauffées à l'électricité et de 198,8 MJ/m^3 par année en moyenne pour les maisons chauffées au moyen d'un combustible fossile. La consommation d'électricité pour le chauffage de l'eau domestique était de 16,4 GJ par année ou de 12,5 kWh/jour et la consommation de combustible fossile pour le chauffage de l'eau était de 30,0 GJ par année ou de 22,8 kWh/jour. La consommation pour l'éclairage et les appareils ménagers était en moyenne de 29,5 GJ par année ou de 22,4 kWh/jour.

Le climat, le volume et la température de l'air à l'intérieur sont les facteurs qui ont le plus influencé la consommation pour le chauffage des pièces et la consommation énergétique totale. Le climat est le facteur qui a eu la plus grande influence sur la consommation pour le chauffage de l'eau. Enfin, le nombre d'occupants et le climat ont eu des répercussions importantes sur la consommation d'énergie pour l'éclairage et les appareils ménagers.

1.0 INTRODUCTION

In 1980, Energy, Mines and Resources Canada, in cooperation with the Canadian Home Builders' Association (CHBA), established the R-2000 Super Energy-Efficient Home Program for the construction of houses to an energy performance target.

The R-2000 Home Program actively supports the evolution and commercialization of energy-efficient housing through the development of consensus standards for products and equipment, laboratory testing of products and equipment, training and education programs for the building industry, public awareness, the development of inspection procedures for quality assurance, and an extensive field monitoring program involving all R-2000 homes.

The objectives of the R-2000 Home Program are:

1. To transfer knowledge on the techniques of constructing and marketing R-2000 homes to as many builders as possible across Canada.

2. To encourage the design, construction and demonstration of a number of R-2000 homes across Canada.

3. To identify and document barriers to the widespread adoption of energy-efficient housing.

4. To document and monitor the construction techniques, problems and energy consumption of houses built under the program to obtain data on the costs, savings and performance of R-2000 homes.

To date, approximately 3000 registered R-2000 homes have been built in Canada.

This report is an update to a previously published report on energy consumption in R-2000 homes [1]. It presents the results of energy monitoring of a sample of R-2000 homes, including analysis to determine whether they are meeting energy performance targets. In addition, a comparison is made between actual measured energy consumption and the predicted energy consumption if built to the requirements of the 1975 National Building Code [2] or the 1983 Measures for Energy Conservation [3].

2.0 CHANGES TO TECHNICAL REQUIREMENTS FOR R-2000 HOMES

The R-2000 Program technical criteria [4] are essentially performance-oriented. This encourages builders to treat the whole house as a system and incorporate the most appropriate combination of features. Several changes have occurred since the last energy consumption report.

The R-2000 energy performance target has evolved through detailed negotiations with the CHBA, Canadian Electrical Association, National Research Council of Canada and provincial representatives.

The current program target is a purchased energy target for space heating and domestic hot water consumption. Previously, the target was calculated on an energy load basis. It was changed to account for the impact of equipment efficiency improvements on energy consumption.

The target varies according to house size, climate zone and type of fuel used for space and water heating. Appliance use is not included in the target, since consumption depends primarily on occupancy and not on house construction or climate zone.

The following formula is used to calculate the energy target:

$$E = [S \times (5 + 55DD/6000) \times M] + \{4745 \times W\}$$

where:

E = annual space and hot water energy consumption target in kWh or MJ.

The term in brackets [] is the seasonal building envelope heat loss or space heating target in kWh or MJ.

S = 4.5 MJ for fuel-fired space heating systems
= 1.0 kWh or 3.6 MJ for electric space heating systems.

DD = annual heating degree-days in Celsius degrees for the location of the home.

M = equivalent floor area in square metres, based on the interior heated volume (m^3) of the house (including basement), divided by 2.5.

The term in braces {} is the annual domestic hot water consumption target.

W = 7.2 MJ for fuel fired domestic hot water (DHW) systems
= 1.075 kWh or 3.87 MJ for electric DHW systems.

The energy target is determined at the plans examination stage by means of a computer simulation program. This program, known as HOT-2000, is based on the HOTCAN Energy Analysis Program[5] developed by the National Research Council for predicting monthly and annual space-heating requirements in residential buildings.

HOT-2000 is available through:

ENERGY ANALYSIS SOFTWARE
P.O. Box 7081, Station J
Ottawa, Ont., K2A 3Z6, Canada
(613) 722-5091

In addition to the energy targets, other technical requirements have evolved.

The efficiency ratings for all heat recovery ventilators are based on testing at 0 and -25 degrees C, performed in accordance with CSA Standard C439, *"Standard Methods of Test for Rating the Performance of Heat Recovery Ventilators"*.

A continuous mechanical ventilation rate of 10 cubic feet per minute (cfm) per habitable room and 20 cfm for basements and utility rooms is now required, instead of an overall rate of 0.45 air changes per hour (ach). The capacity ventilation rate is equal to the continuous rate plus 50 cfm[6].

Monitoring has also shown the average number of occupants is 3 rather than 4 so occupant heat gain has been reduced in HOT-2000 to 2 kWh/day from 3.2 kWh/day.

A normalized leakage area (NLA) value of less than 0.07 cm^2/m^2 at 10 Pa was added to the technical criteria for airtightness of the building envelope as an alternative to 1.5 ach at a fan-induced pressure of 50 Pa. The normalized leakage area criteria was added in order to be compatible with the Canadian General Standards Board (CGSB) standard for testing the airtightness of building envelopes[7].

3.0 MONITORING AND ANALYSIS

3.1 The R-2000 Monitoring Program

To date, the monitoring program has focused on the need for general quality assurance. A number of contaminants have been measured to assess indoor air quality, mechanical ventilation systems have been tested, and energy consumption has been monitored in a sample of R-2000 homes.

Detailed background information has been collected on a significant number of homes. This has included construction plans, a description of the building envelope characteristics including airtightness test results, information on mechanical systems, data on incremental costs of construction, and consumer response and attitudes to R-2000 homes.

The field monitoring activities were carried out in each province and territory in Canada by trained technicians from EMR regional offices. Laboratory and field support was provided by the Ontario Research Foundation (ORF), regional engineering firms and several laboratories in Canada and the United States.

3.2 Energy Consumption Monitoring

The homes were equipped with meters to separately measure energy consumption for space heating and domestic water heating, as well as total consumption. During house visits, EMR regional technicians identified and recorded meter function, multiplier and conversion factors pertaining to the meters, the heating equipment being monitored, and the type of fuel or energy being measured.

EMR regional technicians then provided the occupants with meter reading and card completion instructions and asked them to complete meter reading cards each month and mail these to EMR. Occupants were also asked to allow EMR access to utility bills if verification of the meter readings was required.

Once received at EMR, the meter readings were entered and stored in the Energy Data Base. All readings were checked for accuracy and consistency by EMR personnel. Based on the type and configuration of installed meters identified by the regional technicians during their initial visit, space heating, water heating and total energy consumption were calculated for each home by the Energy Program. The Energy Program was also used to compare consumption with the target and computer predictions of energy consumption.

The Energy Data Base and Energy Program are two of several modules belonging to the Energy Statistics System, which in turn is part of a larger system known as the Residential Technical Information System, which stores detailed information for each home on micro-computer.

The efficiency of the heating equipment was based on the general seasonal efficiency ratings listed below in Table 1. The data on space heating, water heating and total energy consumption, and any other pertinent information in the data base, was then transferred to a file for analysis using MICROSTAT Version 4.0 (trademark of Ecosoft Inc.).

TABLE 1

SEASONAL EFFICIENCY OF HEATING EQUIPMENT

SPACE HEATING EQUIPMENT	EFFICIENCY %
Electric:	
Forced-air furnace	100
Baseboard/hydronic/radiant heaters	100
Gas/Propane:	
Conventional furnace/boiler with pilot	60
Conventional furnace/boiler with spark ignition	63
Conventional furnace/boiler with spark ignition and vent damper	69
Induced draft-fan furnace/boiler	80
Condensing/pulse furnace/boiler	90
Oil:	
Conventional furnace/boiler	60
Conventional furnace/boiler with flue vent damper	63
Conventional furnace/boiler with flame retention head	65
Mid-efficiency furnace/boiler (no dilution air)	75
Condensing furnace/boiler	90
WATER HEATING EQUIPMENT	
Electric water heater (tank, heat pump, etc.)	100
Naturally aspirating gas water heater	55
Induced draft fan gas water heater	58
Naturally aspirating oil water heater	50

3.3 Energy Consumption and Conventional Building Practice

To obtain an indication of energy consumption of the homes if they had been constructed to conventional levels of energy efficiency, additional HOT-2000 computer simulations were generated using insulation values and thermal characteristics specified in the 1975 National Building Code and the 1983 Measures for Energy Conservation. The assumptions and values used for the computer simulations are summarized in Table 1, Appendix A. Actual energy consumption in homes built to these standards will vary according to occupancy, actual weather conditions, and the characteristics of the home when occupied.

4.0 MONITORING RESULTS

4.1 Characteristics of R-2000 Homes

R-2000 homes are characterized by high levels of insulation, control of air leakage by means of improved air barrier sealing techniques, mechanical ventilation systems (often coupled with heat recovery), improved heating systems, and utilization of passive solar energy. The insulation and airtightness characteristics are summarized in Table 1 of Appendix A.

Figure 1 illustrates the percentage of R-2000 homes built in each region of the sample that was monitored and in the program overall. With the exception of houses built in the Yukon and Northwest Territories, the regional cross section of the sample is representative of the overall distribution of R-2000 homes.

Figure 1 REGIONAL DISTRIBUTION OF R-2000 HOMES

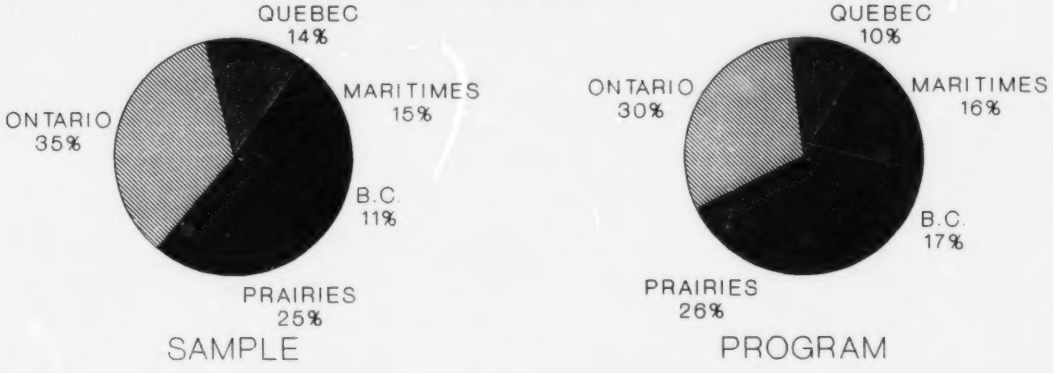
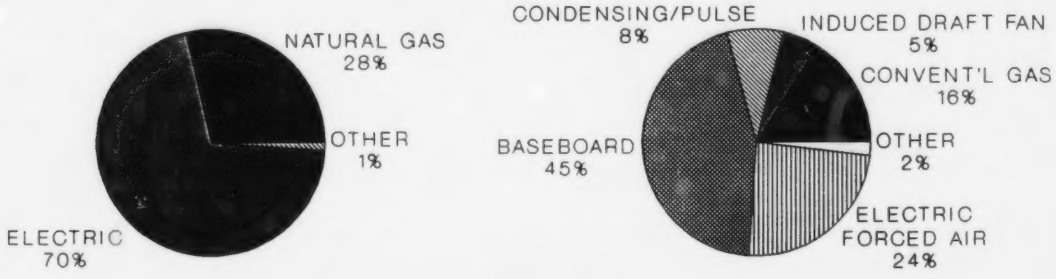


Figure 2 shows that 70% of the sample were heated with electricity and the remainder primarily with natural gas. Approximately 26% had a woodburning appliance, such as a fireplace or woodstove.

Figure 2 SPACE HEATING FUELS AND EQUIPMENT



Statistical analysis of results presented in this report include the arithmetic mean and standard deviation of consumptions and the ratio of measured energy consumption to the target or predicted consumption for individual homes. Student t-tests with a confidence level of 95% were used to determine the statistical significance of the mean and standard deviation of the ratio of measured energy consumption to the target, i.e. when there was a significant difference from the ideal ratio of 1. They were also used to make comparisons between groups of houses with different characteristics. The difference between measured energy consumption and predicted reference standard home energy consumption is presented as well. Some linear regression analysis was done to determine significant factors impacting on consumption. Graphs are used to show many of the results and the relationships between different groups of homes.

The differences between the ratios of actual consumption to the target or prediction and the ideal ratio of 1 may appear to be large, while the absolute difference in kWh/day may be small. This is due to the extremely low energy consumption in some homes, and most evident in small homes and those in warm weather zones, where small differences in actual consumption can appear to be large when expressed as percentages or ratios.

4.2 Space Heat Consumption

The space heating energy consumption sample consists of the data for those homes with meter readings for the combination of both the 1985/86 and 1986/87 heating seasons and those with data for one or the other of those heating seasons. The space heating season was defined as September 15 to April 15. It was necessary to specify the heating season since many of the space heating meters also recorded energy consumption for other purposes such as air conditioning and continuous furnace fan usage throughout the year. The data is presented for a combination of heating seasons in order to obtain averaged results and reduce fluctuations caused by unusual weather patterns. As well, home consumptions are compared against the program target and the target is based on average weather data.

The analysis is presented for 140 homes. The data base contained 249 homes for which there were any readings over the required time period. Of these homes, 109 were eliminated from the sample because of insufficient meter readings. The criteria for the minimum number of days covered by the meter readings was 315 days for a two-year period and 160 days for a one-year period. This ensured that at least half of the coldest part of the heating season was analyzed. Sixty-four cases had readings for the two-year period; the remainder were homes with single-year readings. Previously, homes with seemingly abnormal high or low readings were rejected. There were eight such cases and they were retained for this analysis.

Consumption levels of electric and fossil fuel heated homes are presented separately because they have different space heating equipment efficiencies which affect consumption.

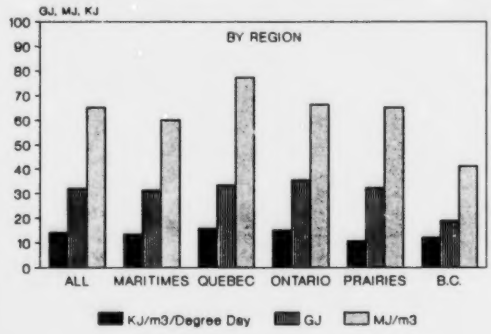
4.2.1 Electric Space Heating Consumption

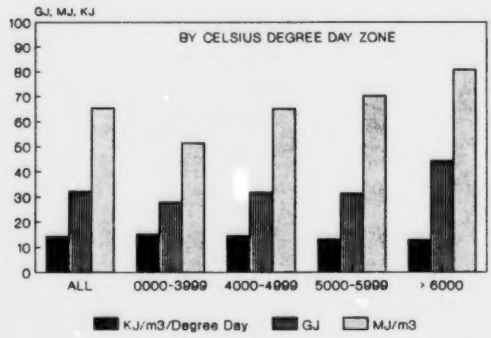
The average space heating consumption per electrically heated R-2000 home was 32.2 GigaJoules (GJ) per heating season over the two heating seasons examined (Sept. 15, 1985 to April 15, 1986 and Sept. 15, 1986 to April 15, 1987). Detailed results are presented in Table 1 of Appendix B.

Consumption was comparable between regions except for British Columbia, where significantly less energy for space heating was used. This difference is attributed to the province's warmer climate. Dividing the consumption by the volume of the house and the number of degree days equalizes the effects of volume and climate on consumption across the regions. The consumption per m^3 per degree day for homes in B.C. (12.2 kJ/m^3/ degree day) was comparable to that of other regions, being greater than that of Prairie homes (10.7 kJ/m^3/degree day) and slightly below that of Maritime homes (13.5 kJ/m^3/degree day).

While electric space heating consumption tended to increase in colder zones, homes in the 5000-5999 degree day zone did not follow this pattern. They consumed about the same amount of energy as those in the 4000-4999 zone. This was because most of the homes in the 5000-5999 range have smaller volumes and consequently need less space-heating energy. This was verified by examining the consumption per cubic metre, which increased consistently from 51.3 MJ/m^3 to 80.9 MJ/m^3 as degree day zones became colder. After accounting for the effects of volume and climate on space heating, consumption was comparable between climate zones and ranged from 13.0 kJ/m^3/degree day to 15.0 kJ/m^3/degree day. This is consistent with the intention of the R-2000 Program energy target.

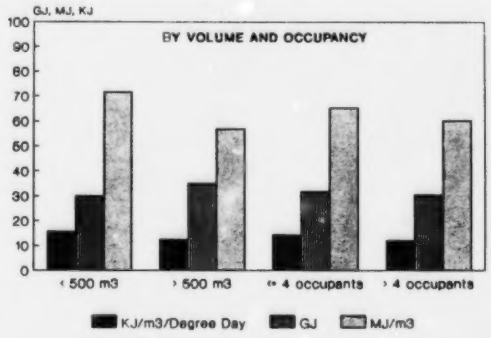
Figure 3
ELECTRIC SPACE HEATING CONSUMPTION





As the average house volume increased from less than 500 m^3 to more than 500 m^3, space heating consumption also increased, from 30.1 GJ to 35.1 GJ per home over the heating season. In larger homes there is a greater volume to heat and a greater area of heat loss. The average volume was 417 m^3 for homes under 500 m^3 and 631 m^3 for homes over 500 m^3. However, consumption normalized by volume and climate was much lower, on average, in homes with volumes greater than 500 m^3, 12.5 kJ/m^3/ degree day versus 15.7 kJ/m^3/ degree day. It is more efficient to heat each cubic metre of larger homes since the ratio of heat loss area to heating volume decreases as the volume increases.

Figure 4
ELECTRIC SPACE HEATING CONSUMPTION



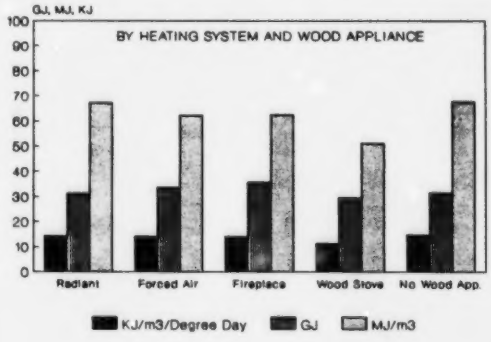
Total space heating consumption, consumption per m^3 and consumption per m^3 per degree day decreased as the number of occupants increased. Average occupancy was 2.9 for homes with four or fewer people and 5.1 for homes with more than four people. The sample size for homes with more than four occupants was small, and the difference was not statistically significant. More occupants will by themselves generate more heat, and also use more appliances, lights and hot water, all of which contribute heat. The house volume, however, will tend to be larger to accommodate the occupants, and this will offset these heat gains.

Homes with forced air furnaces used slightly more energy than homes with radiant systems, but the homes with forced air heating were significantly larger. Consumption per cubic metre was therefore actually smaller in homes with forced air heating systems.

Space heating energy consumption was higher for homes with fireplaces and lower for those with wood stoves in relation to homes with no wood appliances.

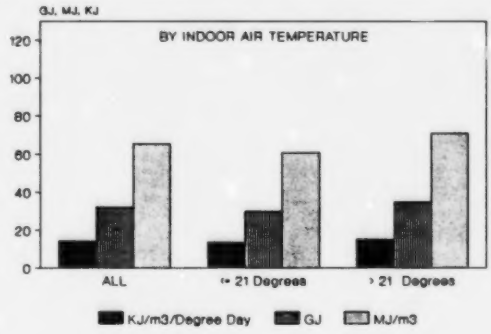
The homes with fireplaces were larger on average than the others, and consumption per cubic metre was lower than in those with no wood appliances. Homes with wood stoves had the lowest consumption overall when normalized for the effects of volume and climate.

Figure 5
ELECTRIC SPACE HEATING CONSUMPTION



The average consumption of homes with indoor air temperatures less than or equal to 21°C was lower than those with indoor air temperatures greater than 21°C. This relationship remained consistent after consumption was adjusted for both volume and climate, but none of the differences were significant. The average temperatures for the two groups were 19.7° and 22.9°C.

Figure 6
ELECTRIC SPACE HEATING CONSUMPTION



The results of linear regression analysis of electric space heating consumption showed that climate zone, volume and indoor air temperature were significant factors at the 95% confidence level. All coefficients for the variables were in the expected direction, and the adjusted R^2 indicates that 42% of the variance in consumption can be explained by these variables. The regression results were better using total energy consumed over the space heating season as the dependent variable. Those same variables accounted for 46% of the variance in total energy consumption.

Several different combinations of variables were used in the attempt to find an explanation for the variation in heating consumption. A dummy variable for the presence of a wood stove was significant in the equation for total energy use over the space heating season and improved the fit of the equation to 53%. This variable was not, however, significant in the equation for space heating, and the fit improved only slightly, to 43%.

Air change per hour was a significant variable in all equations, but it is closely related to house volume. Therefore, air change per hour and volume could not be used together in the same equation, making it impossible to determine which is actually explaining the variation in consumption. In the end, volume provided slightly better results than air change per hour.

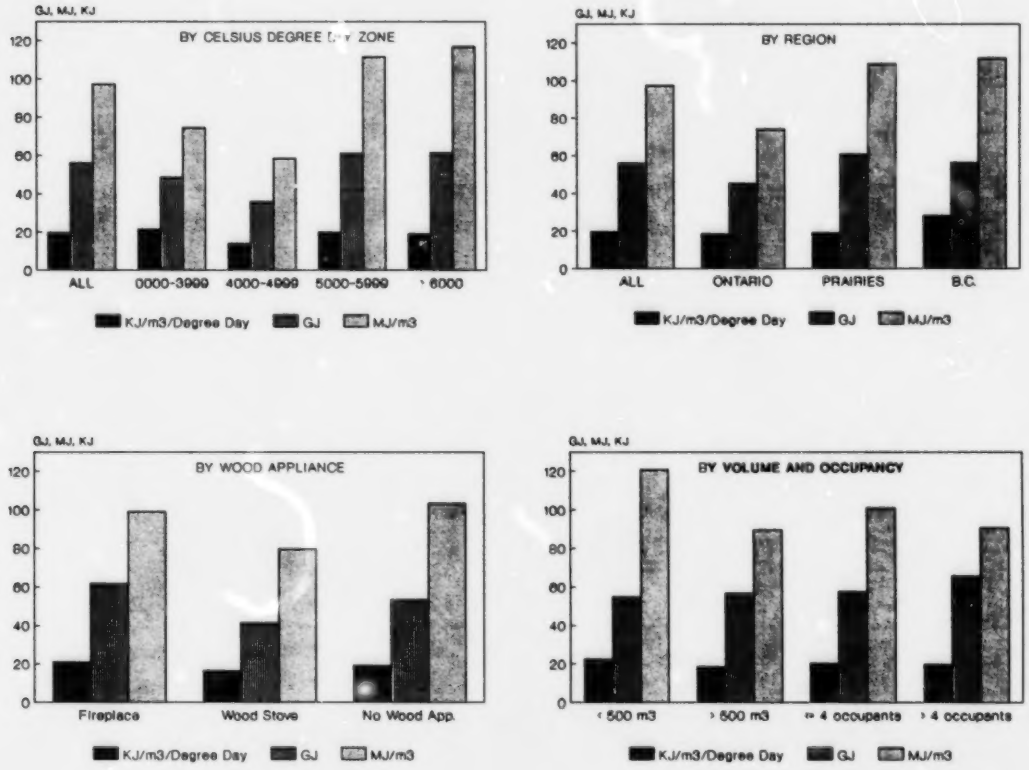
The variable next closest to being significant was the ratio of exhaust to supply ventilation air from the HRV. In some cases, it was a significant variable when used in combination with air change per hour rather than house volume. The coefficent was negative which means that consumption decreased as the ratio increased. This result is interesting and may be the result of several factors. A ratio of exhaust to supply air greater than one means that the house is under negative pressure, air is being drawn into the house from the outside. A possible theory for this phenomenon is based on the Shaw air infiltration model[8]. By operating the ventilation system of a house at a negative pressure, warm air from the house cannot escape to the outside through leaks since air is being pulled in from the outside. In addition, there could be a dynamic wall effect, where the outside air is preheated as it passes through the walls of the house. Finally, some HRVs may not need to pass through a defrost cycle as frequently, since there is more warm air being transferred to the supply air than if the HRV was operating in a balanced mode.

The equations are presented in Appendix C.

4.2.2 Fossil Fuel Space Heating Consumption

The average consumption over the space heating seasons for homes heated with fossil fuels was 56.2 GigaJoules, shown in Table 2 of Appendix B. The sample size for this group of homes was small, 35 homes, which made further analysis questionable. There was also a wide variation in the efficiency of the heating equipment used (69% to 90%) because many older R-2000 homes were included. This will also have an effect on the statistics of a small sample. The trends were similar to those found in electric homes, with the exception of consumption in British Columbia. The seasonal efficiency of heating equipment may be lower in B.C., because heating requirements are not as great in a warmer climate, which reduces the intensity and duration of furnace operation. The energy consumption of newer homes will be more consistent because of program technical requirements that require a minimum space heating equipment efficiency of 80%.

Figure 7 FOSSIL FUEL SPACE HEATING CONSUMPTION



4.2.3 Comparison With R-2000 Space Heating Target

On average, R-2000 homes consumed 4% less energy for space heating than the program target to which the homes were designed. The frequency distribution at right shows that the consumption of 55% of the homes was within 20% of the target. Eight-two per cent of the houses had consumptions less than 20% above the target.

Figure 8 ACTUAL/TARGET FREQUENCY DISTRIBUTION

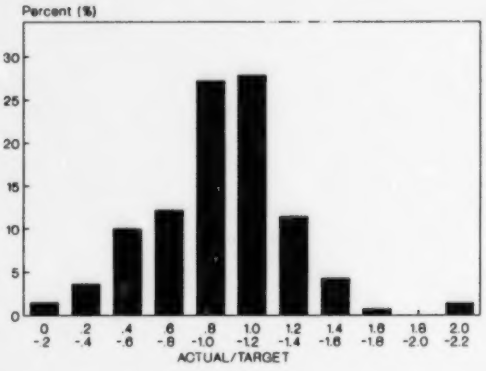
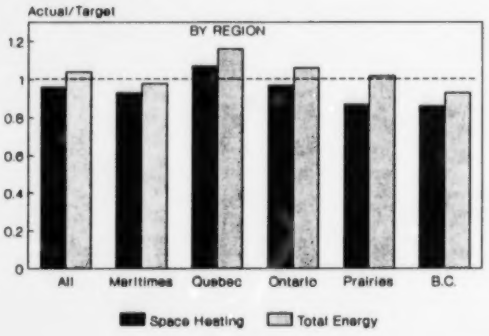


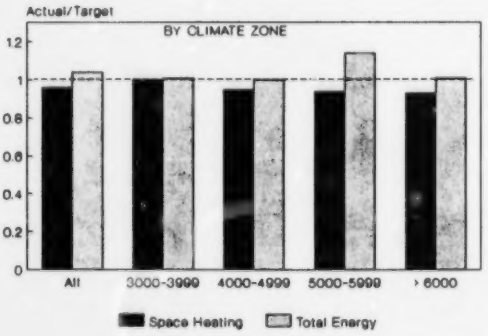
Table 4 of Appendix B shows the ratios of actual consumption to the target for space heating and total energy use over the space heating season. The ratio of total energy to the target is included to demonstrate that other uses of energy in the home will provide heat and possibly reduce the need for space heating.

The only significant regional difference from the space heating target was in the Prairies, where consumption was 13% lower than the target. However, the average total energy consumption for the space heating season in the Prairies was nearly equal to the average of the targets. Homes in British Columbia consumed 14% less energy than the target, but this difference was not significant because of the small sample size.

Figure 9 COMPARISON WITH TARGET



Homes in colder climates performed marginally better against the target than those in warmer areas. However, more total energy relative to the target was used in colder regions, suggesting that more heat energy in these homes came from sources other than the heating system itself. More total energy is required for lighting in colder climates because of fewer daylight hours.



Homes with volumes greater than 500 cubic metres used significantly less energy (14%) for space heating than the target. Possible reasons for this include higher occupancy, greater light and appliance use, lower air changes and the greater heating efficiency of larger houses.

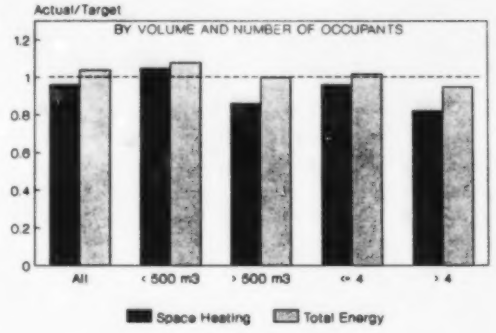
Consumption in homes with more than four occupants was 18% less than the target. This difference was not significant because of the small sample size. Total energy use for the space heating season was much closer to the target, indicating again that space heating requirements are not being supplied exclusively by the heating system.

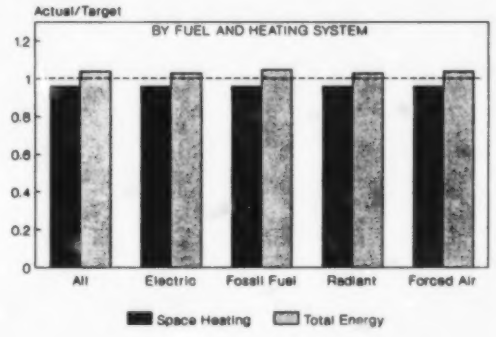
Houses with both heating system types used slightly less energy for space heating on average than the target.

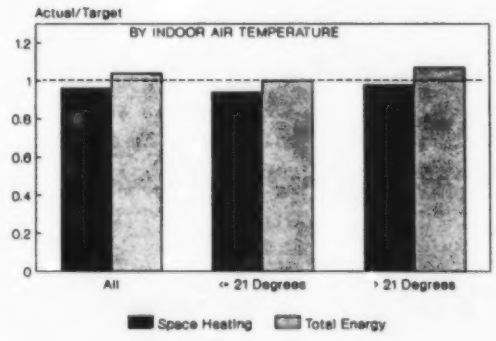
Homes with wood stoves used significantly less purchased energy than targeted. Actual wood use was not measured and the contribution was not included in the calculations.

The figure at right shows that the consumption of homes with indoor air temperatures less than or equal to 21°C was 4% less than the target. The consumption of homes with indoor air temperatures greater than 21°C was 2% below the target.

Figure 10
COMPARISON WITH TARGET



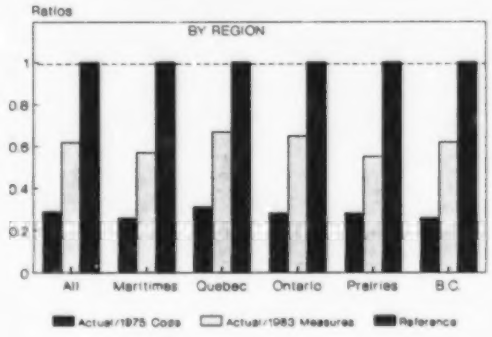


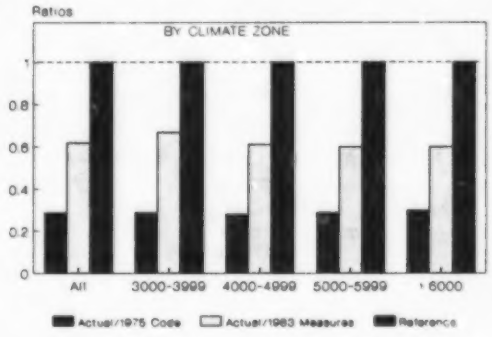


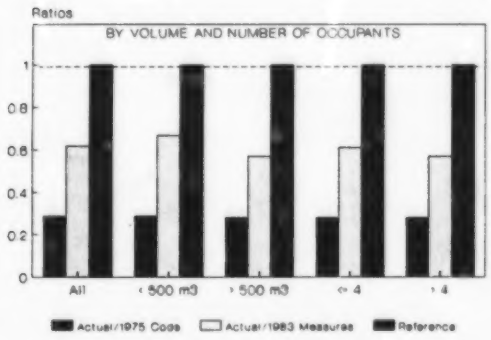
4.2.4 Comparison of Space Heating Consumption With Conventional Building Practice

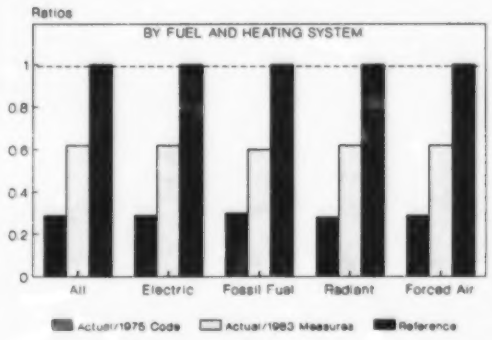
Figure 12 shows the relationship between actual space heating consumption and the predictions for 1983 and 1975 standards. The first two bars of the clusters show the ratios of actual consumption to each standard. The third bar represents the level at which actual consumption would equal the standards and is provided as a reference. The figures show that measured space heating consumption in R-2000 homes is equal to about 30% of the requirements for the same home built to the 1975 building code. This represents a saving of 93.5 GJ per house over the heating season. Similarly, R-2000 space heating consumption is approximately 60% of that of homes built to the 1983 Measures for Energy Conservation, which represents a saving of 23.4 GJ per heating season per house.

Figure 11 COMPARISON WITH CONVENTIONAL BUILDINGS









4.3 Total Annual Energy Consumption

4.3.1 Total Annual Energy Consumption - Electrically Heated Homes

The average annual total energy consumption for electrically heated R-2000 homes was 74.8 GigaJoules, 152.5 MJ/m^3 or 33.7 kJ/m^3/ degree day (Appendix B, Table 6).

Total consumption was comparable between homes in different regions, with the exception of those in British Columbia, which used 51.7 GJ/year total energy, which was significantly less than homes in all other regions.

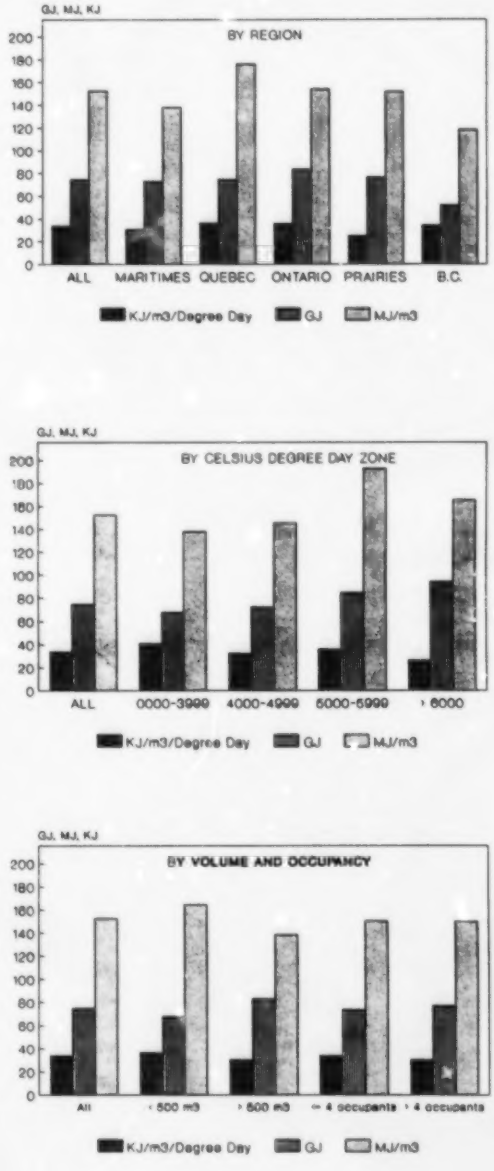
Consumption per cubic metre was also lowest in B.C. at 118.6 MJ/m3, and highest in Quebec at 176.1 MJ/m^3. Consumption normalized by volume and climate was comparable between Ontario, Quebec and B.C. and lower in the Maritimes and the Prairies.

Houses in progressively colder areas consumed more energy. The lowest consumption was 67.6 GJ/year in the 3000-3999 degree day zone. The highest consumption was 94.1 GJ/year in the greater than 6000 degree day zone. However, when normalized by volume and climate, total consumption was actually highest in the 3000-3999 degree day zone at 40.8 kJ/m^3/degree day and lowest in the coldest zone at 26.4 kJ/m^3/degree day.

Total consumption was 68.0 GJ/year in homes with volumes less than 500 m^3 and 83.0 GJ/year in homes with volumes greater than 500 m^3. The average volume was 417.5 m^3 in homes with volumes less than 500 m^3 and 614.1 m^3 in homes with volumes greater than 500 m^3. Consumption adjusted for climate and volume was lower, 30.5 kJ/m^3/degree day in the larger homes, compared to 36.4 kJ/m^3/degree day in the smaller homes.

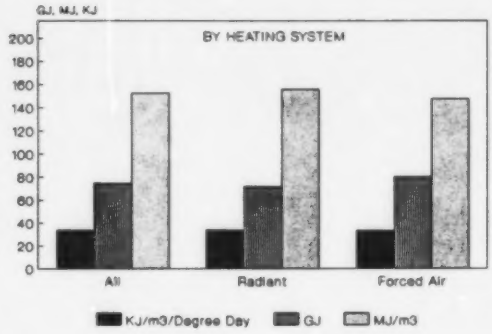
Total consumption per year was greater in homes with higher occupancy. However, consumption normalized by climate and volume was lower in homes with more than four occupants.

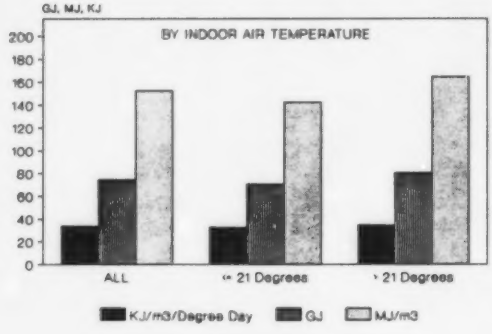
Figure 12
TOTAL ENERGY CONSUMPTION



Homes with forced air heating systems used more energy than those with radiant systems, 80.1 GJ/year versus 71.6 GJ/year. This is primarily due to house size. Houses with radiant heating equipment consumed slightly more energy by volume, 155.7 MJ/m^3 compared to 147.3 MJ/m^3. Houses with radiant heating systems also consumed slightly more total energy by volume and climate. The figures were 34.0 kJ/m^3/degree day for radiant heating and 33.3 kJ/m^3/degree day for forced air heating.

Figure 13
TOTAL ENERGY CONSUMPTION





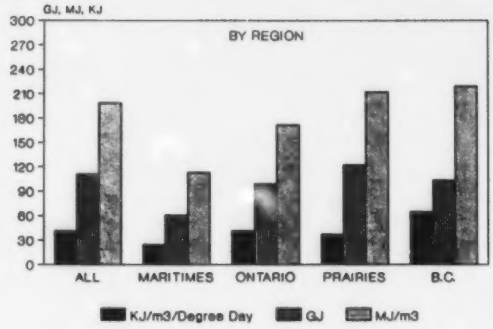
Homes with indoor temperatures of 21°C or lower consumed significantly less total energy on average than those with temperatures above 21°C. This was also true after the consumptions were normalized by volume. Consumption adjusted by both volume and climate was also lower in homes with temperatures of 21°C or lower, but the difference wasn't significant.

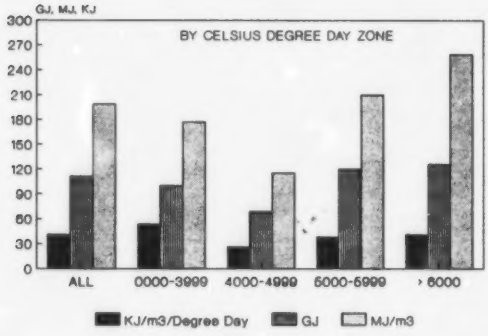
Regression analysis of total energy consumption for electrically heated homes showed that climate, volume, indoor air temperature and the use of wood stoves were significant at the 95% confidence level and could explain 51% of the variance in consumption. The ratio of exhaust over supply air from the HRV was the next best but not significant explanatory variable.

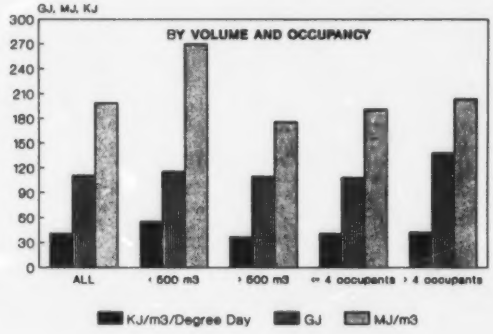
4.3.2 Total Annual Energy Consumption - Fossil Fuel Heated Homes

The average annual total energy consumption for R-2000 homes heated with fossil fuels was 111.2 GigaJoules (Appendix B, Table 6). Analysis of the results is not presented because of the small number of homes in the sample.

Figure 14 FOSSIL FUEL HEAT TOTAL ENERGY CONSUMPTION







4.3.3 Comparison with Total Annual Energy Prediction

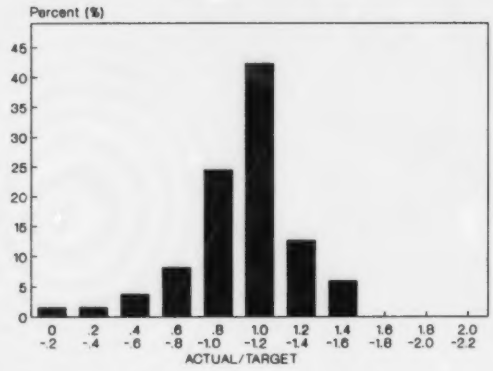
The R-2000 Program uses a purchased space heating and DHW energy consumption target with no target for total energy consumed. For the purpose of this report, a comparison is made between actual consumption and a prediction for total energy. Sixteen kWh per day for lights and appliances use was added to the program target in order to obtain the prediction.

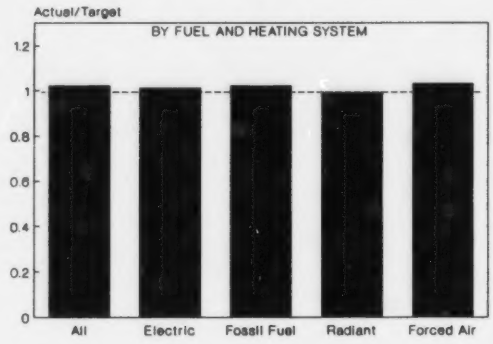
The frequency distribution for the ratio of actual consumption to the prediction shows that two-thirds of the sample were within 20% of the prediction. Eighty-one per cent of the homes had total energy consumption of less than 20% above the prediction.

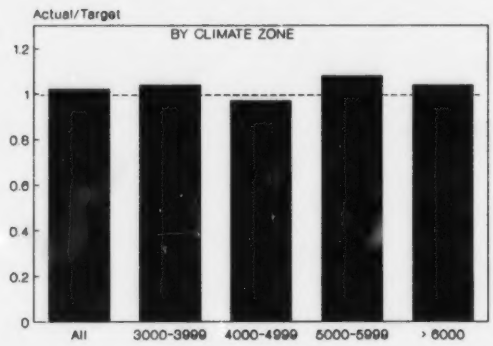
Average total energy consumption of homes with both electric and fossil fuel space heating equipment was 2% more than the average predicted value (Table 7, Appendix B).

There was little difference between average consumptions and predictions for houses with different characteristics, but one significant difference was higher consumption for homes located in the 5000 to 5999 degree day range.

Figure 15
COMPARISON WITH PREDICTION





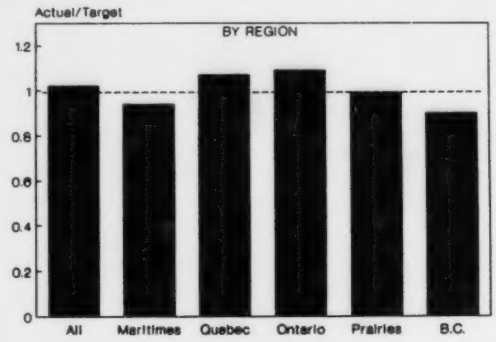


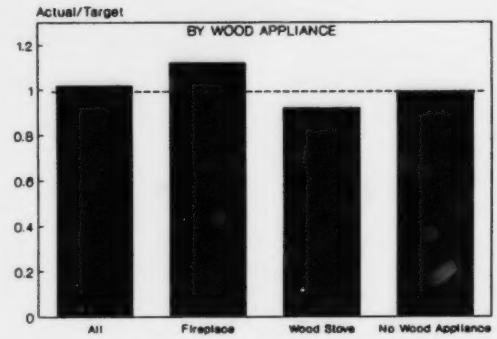
Homes in Quebec and Ontario consumed 7% and 9% more than the total prediction, respectively. Homes in British Columbia used 10% less energy than the prediction. None of the provincial differences from the prediction was significant.

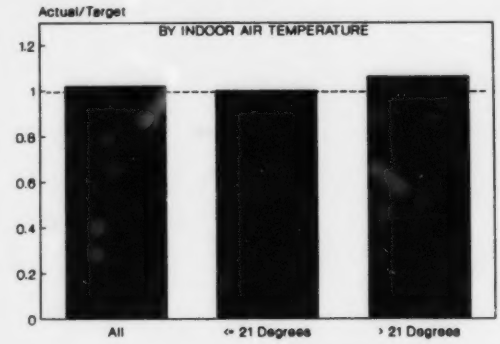
The other significant differences between total actual consumption and the prediction were that homes with fireplaces used 12% more energy than the prediction and homes with woodstoves used 8% less energy than the prediction. As mentioned earlier, homes with fireplaces are, on average, larger than those without fireplaces.

The average total consumption was equal to the average of the prediction in homes with indoor air temperatures of 21°C or lower and slightly greater than the prediction in homes with indoor air temperatures of more than 21°C.

Figure 16
COMPARISON WITH PREDICTION



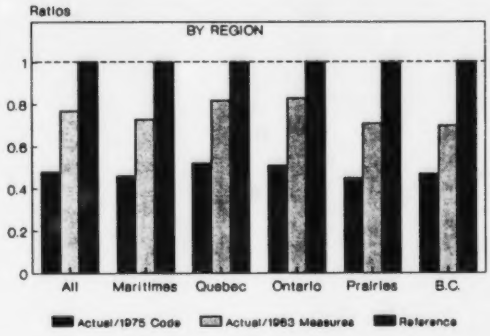


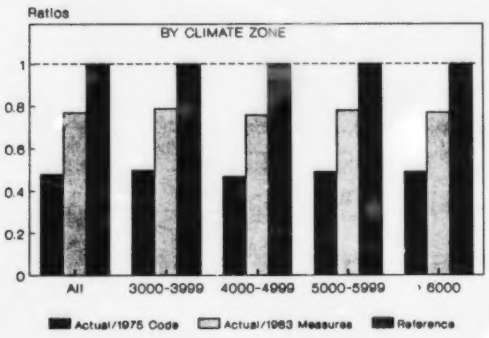


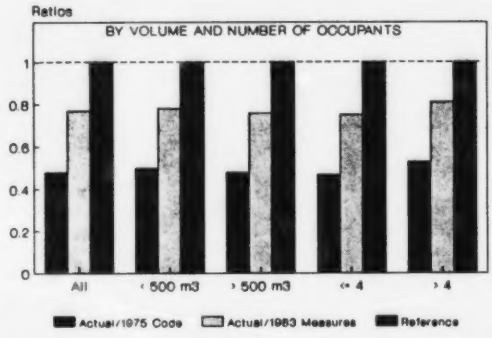
4.3.4 Comparison of Total Energy Consumption with Current Building Practice

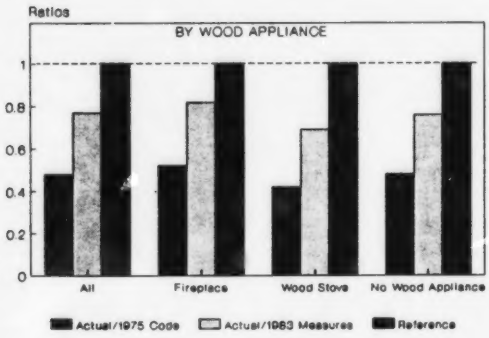
Average total energy consumption in R-2000 homes was equal to 48% of the estimated use for homes built to the 1975 Building Code and 77% of the estimated use for homes built to the 1983 Measures for Energy Conservation. The estimated annual savings for total energy consumption are 91.2 and 25.8 GJ respectively.

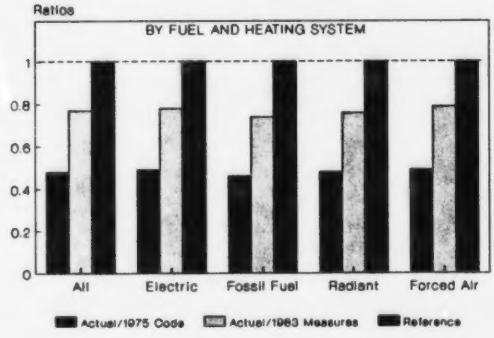
Figure 17 COMPARISON WITH CONVENTIONAL BUILDINGS











4.4 Domestic Water Heating

4.4.1 Electric Domestic Water Heating

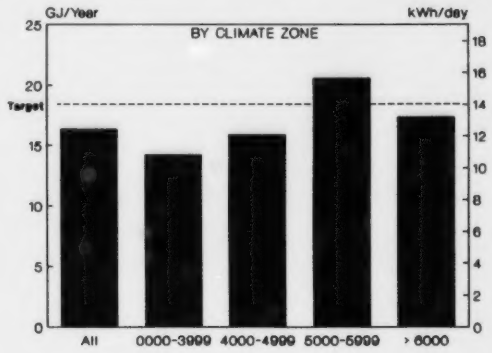
Average electric water heating consumption was 16.4 GigaJoules per year, or 12.5 kWh/day (Appendix B, Table 9).

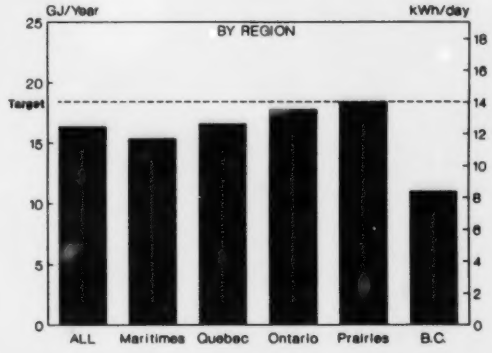
Electric water heat consumption tended to increase in colder zones. There was a low of 14.2 GJ per year in the 3000-3999 degree day zone and a high of 20.6 GJ per year in the 5000-5999 degree day zone. Significant differences in climate zone consumption were found between homes in the 5000-5999 and 4000-4999 zones and the 5000-5999 and 0000-3999 zones.

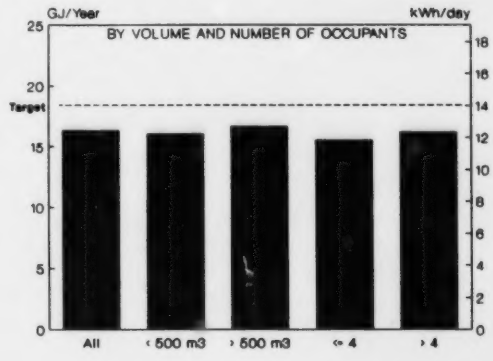
Residents of homes in British Columbia used significantly less energy for water heating (11.0 GJ/year) than those of all the other provinces except the Maritimes. This seems to be climate related, which in turn may be linked to the supply temperature of the water.

There was almost no difference in hot water consumption between houses with different volumes and between houses with four or fewer occupants and those with more than four occupants.

Figure 18
ELECTRIC DHW CONSUMPTION



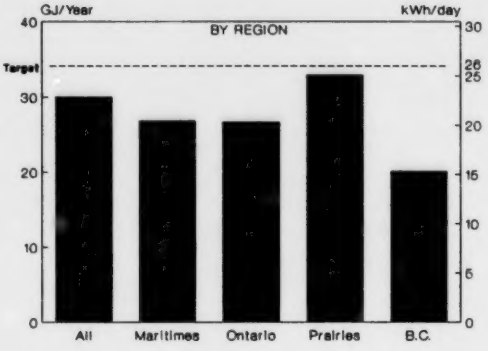


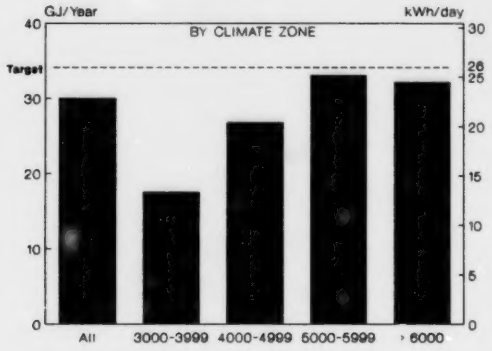


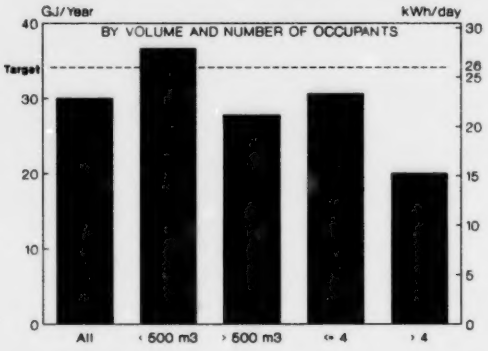
4.4.2 Fossil Fuel Domestic Water Heating

Average fossil fuel water heating consumption was 30.0 GigaJoules per year or 22.8 kWh/day (Appendix B, Table 10). The size of the sample, 24 homes, precluded any analysis of differences in consumption between different house characteristics.

Figure 19
FOSSIL FUEL DHW CONSUMPTION







4.4.3 Comparison with Domestic Water Heating Target

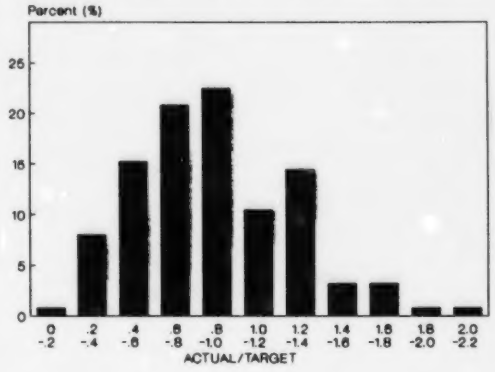
Of the sample, 53% were within 20% of the program target for hot water consumption. Seventy-eight per cent of the sample had consumptions less than 20% above the target.

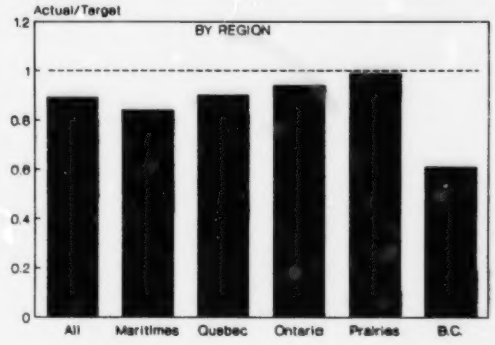
The average water heating consumption for all fuels was 11% lower than the R-2000 program target (Appendix B, Table 11). This difference was significant.

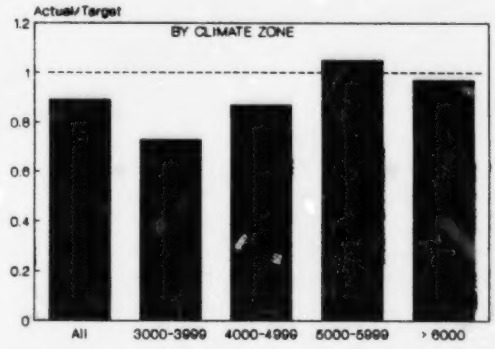
Regionally, the Maritime provinces and British Columbia used significantly less energy for water heating than the target.

Only those homes in warmer climates used significantly less energy than the target. These were homes in the 0000-3999 and 4000-4999 degree day zones.

Figure 20
COMPARISON WITH TARGET



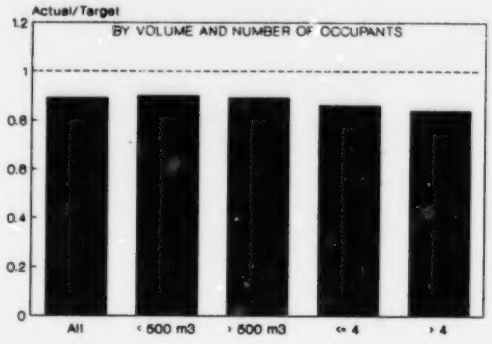


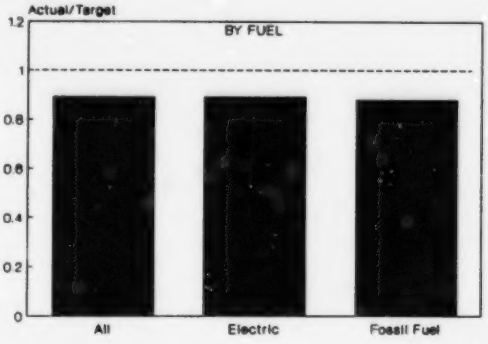


There were other significant differences between actual water heating consumption and the target. The consumption of both smaller and larger house volumes was below the target, homes with four or fewer occupants used less energy than the target and electric water heating consumption was under the target.

The ratio of actual consumption to the target was lower for fossil fuel water heating than for electric water heating, but the sample was too small for the difference to test significantly.

Figure 21
COMPARISON WITH TARGET





These results show that hot water consumption is overestimated by the program target. Monitoring visits to homes by field technicians indicate that many people have installed extra insulation jackets on their hot water tanks which will reduce consumption.

The results also indicate that climate is the factor which has the greatest effect in the determination of domestic hot water consumption. Regression analysis of electric hot water consumption using climate, occupancy and indoor air temperature as the explanatory variables showed that climate was the only significant variable at the 95% significance level. All three variables together could only explain 13% of the variance in consumption. The Durbin-Watson test statistic for the regression indicated that the part of consumption unexplained by the regression equation was correlated to consumption, which suggests that an explanatory variable is missing from the equation. Further regressions were unsuccessful in eliminating this correlation from the residual.

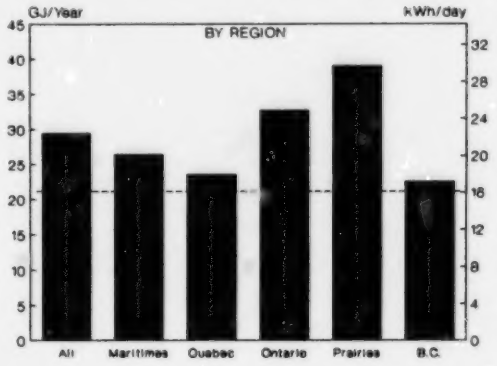
4.5 Lights and Appliances Consumption and Comparison with R-2000 Assumptions

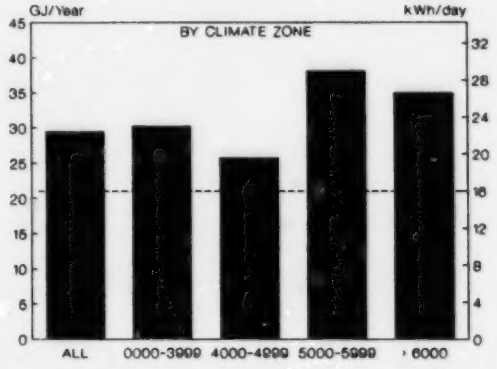
Lights and appliances consumption was calculated by subtracting space heating and domestic hot water consumption from total consumption for those homes that had readings for all three categories.

The average annual lights and appliances consumption was found to be 22.4 kWh/day, or 29.5 GigaJoules per year (Appendix B, Table 12). Average electrical consumption for lights and appliances use is assumed to be 16 kWh/day or 57.6 MJ/year by the HOT-2000 program in order to predict total energy consumption. Overall actual consumption was 40% greater than the assumed average consumption and all consumptions broken down by the various house characteristics were significantly greater than the assumed average (Appendix B, Table 13). However, actual consumption was 10% less than the guideline of 25 kWh/ day for high consumption provided by HOT-2000 which was also a significant difference.

Several significant provincial differences in consumption were found. Homes in British Columbia used less energy (22.5 GJ/year) than all other homes except those in Quebec (23.5 GJ/year). Prairie and Ontario homes used more, 39.0 and 32.7 GJ per year respectively, than all other provinces.

Figure 22
LIGHTS AND APPLIANCES CONSUMPTION





Homes in colder degree day zones tended to have greater lights and appliance consumption, although this difference was not true between each zone. Specific significant differences were found between homes in the greater than 6000 degree day zone and those in the 4000-4999 zone and between homes in the 5000-5999 zone and all those in warmer zones. Homes in colder zones will probably use more energy for lighting and car block heating because of fewer daylight hours and colder temperatures.

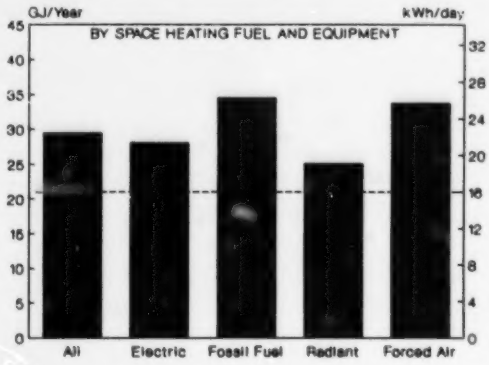
Homes with fossil fuel space heating equipment used more energy (34.5 GJ/year) for lights and appliances than those heated with electricity (28.0 GJ/year). The statistics for radiant and forced air heating show lights and appliances consumption was significantly lower in homes with radiant heat, 25.1 GJ/year compared to 33.7 GJ/year. Once consumption was adjusted for volume and climate, however, these differences were no longer present.

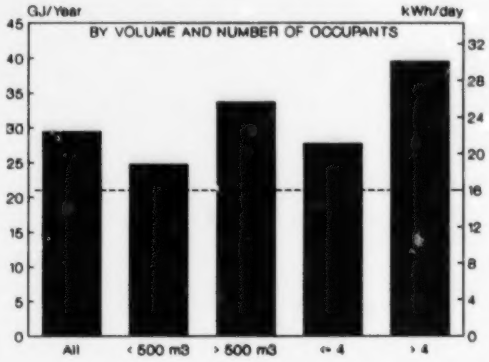
A number of differences were significant within house characteristic groups. As would be expected, small homes used less energy than larger homes, 24.7 GJ/year versus 33.6 GJ/year. Houses with four or fewer occupants used less energy at 27.7 GJ/year than those with more than four occupants at 39.5 GJ/year. Fewer people will use fewer lights and appliances.

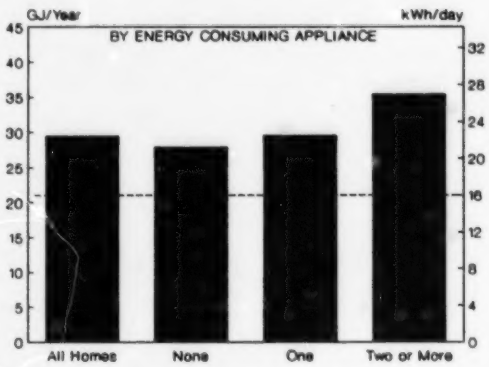
Actual consumption increased with the number of energy-consuming appliances, and homes with two or more energy-consuming appliances used significantly more energy (35.4 GJ/year) than those with one (29.6 GJ/year) or no energy consuming appliances (27.9 GJ/year).

The number of energy-consuming appliances was compiled from homeowner survey information.

Figure 23
LIGHTS AND APPLIANCES CONSUMPTION







The appliances were selected by homeowners from the following list:

Indoor Energy Intensive Uses	Outdoor Energy Intensive Uses
Well pump	Outdoor pool
Sump pump	Electric gardening tools
Sauna	Yard lighting
Workshop	Separate workshop
Indoor pool	Heated walk/driveway
Whirlpools	
Energy intensive hobbies	
Garbage compactor/shredder	
Central vacuum	

TABLE 2

LIGHTS AND APPLIANCES CONSUMPTION

CHARACTERISTIC	< 25 kWh/day	> 25 kWh/day
CLIMATE ZONE		
<= 5000 degree days	82%	53%
> 5000 degree days	18%	47%
VOLUME		
<= 500 m^3	55%	31%
> 500 m^3	45%	69%
OCCUPANCY		
<= 4 occupants	75%	32%
> 4 occupants	25%	68%
ENERGY CONSUMING APPLIANCE		
<= 1 appliance	55%	47%
> 1 appliance	45%	53%
SPACE HEATING EQUIPMENT TYPE		
Radiant	54%	36%
Forced Air	46%	64%

This table suggests that all factors have some impact on lights and appliances consumption. Some of the factors are interrelated, e.g., larger houses will tend to have forced air heating, higher occupancy and more appliances. Regression analysis of lights and appliances consumption showed that 35% of the variance in consumption could be explained by these variables, excluding volume. Three of them were significant at the 95% confidence level: heating equipment type, climate zone and occupancy. The equation is presented in Appendix C.

5.0 CONCLUSIONS

On average, space heating energy consumption was 4% less than the program target. Total energy consumption was 2% greater than the prediction. Water heating consumption was 11% below the target. Consumption for lights and appliances use was 40% greater than the assumptions used in the HOT-2000 energy analysis program. The R-2000 program uses a combined space heating and domestic hot water purchased energy target, so the average consumption of R-2000 homes was well below the program target.

R-2000 home space heating consumption was equal to 29% of the consumption predicted for homes built to the 1975 National Building Code and 62% of the consumption predicted for homes built to the 1983 Measures for Energy Conservation. This corresponds to savings of 93.5 GJ and 23.4 GJ per heating season per house, respectively. Total energy consumption was equal to 48% of the consumption predicted for homes built to the 1975 National Building Code and 77% of the consumption predicted for homes built to the 1983 Measures for Energy Conservation. This represents annual savings per home of 91.2 GJ and 25.8 GJ respectively. Actual lights and appliances consumption was greater than assumed which reduced the total energy savings predicted.

Average space heating consumption in electrically heated homes was 32.2 GigaJoules (GJ) per heating season, compared with 56.2 GJ per heating season in homes heated with fossil fuels. Average total energy consumed was 74.8 GJ per year in homes with electric space heating, 111.2 GJ in homes with fossil fuel space heating. Electric domestic hot water consumption was 16.4 GJ per year or 12.5 kWh/day, while fossil fuel water heating consumption was 30.0 GJ per year or 22.8 kWh/day. Lights and appliances consumption averaged 29.5 GJ per year or 22.4 kWh/day.

Climate, volume and indoor air temperature were the factors that had the greatest impact on space heating energy consumption. Regionally, space heating consumption was lowest in B.C., but after adjustment for the effects of volume and climate, it was comparable to that of other regions. Space heating consumption was greater in colder climate zones, but again, once adjusted for volume and climate effects, it was comparable between climate zones. This is the intention of the R-2000 Program. Space heating consumption increased with volume as expected, however consumption per cubic meter and consumption per cubic meter per degree day was lower in houses with large volumes. Space heating consumption was greater in homes with higher indoor air temperatures. There was also some variance in consumption by space heating equipment type but this was related to house size and climate rather than equipment type. Wood stoves, however, did reduce space heating consumption.

Climate, volume and indoor air temperature were also the factors that had the greatest impact on total energy consumption. The trends were very similar to those found in the analysis of space heating consumption.

Climate was the strongest factor affecting hot water consumption. Occupancy and climate had a significant impact on consumption for lights and appliances.

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3. Associate Committee on The National Building Code of Canada, 1983 Measures for Energy Conservation in New Buildings, National Research Council of Canada, NRCC 22432

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8. Shaw, C.Y., "The Effect of Mechanical Ventilation on the Air Leakage Characteristic of a Two-Storey Detached House", Division of Building Research, National Research Council of Canada, Building Research Note 204, 1983

APPENDIX A

TABLE 1

REFERENCE STANDARDS

1975 National Building Code		CELSIUS DEGREE DAY ZONE				
		up to 3333	4444	5556	6667	7778
Ceilings	RSI	1.73	2.08	2.38	2.64	2.89
Main Walls	RSI	1.73	2.08	2.38	2.47	2.47
Basement Walls:						
Above Grade	RSI	1.48	1.48	1.48	1.48	1.48
2 ft. Below Grade	RSI	1.48	1.48	1.48	1.48	1.48
2 ft. to Footing	RSI	0.00	0.00	0.00	0.00	0.00
Basement Floor	RSI	0.00	0.00	0.00	0.00	0.00
Doors	RSI	0.40	0.40	0.40	0.40	0.40
Glazing/Windows	RSI	0.20	0.20	0.20	0.36	0.36
Average R-2000 Values		**up to 3333**	**4444**	**5556**	**6667**	**7778**
Number of Homes		14	43	79	29	1
Ceilings	RSI	6.10	7.30	7.91	9.66	7.92
Main Walls	RSI	4.79	5.12	5.41	6.01	5.39
Basement Walls:						
Above Grade	RSI	3.31	3.43	3.93	4.71	4.14
2 ft. Below Grade	RSI	3.31	3.44	3.66	4.45	3.74
2 ft. to Footing	RSI	3.31	3.44	3.53	4.16	3.62
Basement Floor	RSI	1.55	0.25	0.76	0.55	0.65
Doors	RSI	0.39	0.43	0.42	0.45	0.43
Glazing/Windows	RSI	0.29	0.29	0.31	0.37	0.32

TABLE 1 (cont'd)

REFERENCE STANDARDS

1983 Measures For Energy Conservation		CELSIUS DEGREE DAY ZONE			
		up to 3500	5000	6500	8000
Ceilings	RSI	4.7	5.6	6.4	7.1
Main Walls	RSI	3.0	3.6	4.1	4.5
Basement Walls:					
Above Grade	RSI	2.2	2.2	2.2	2.2
Below Grade	RSI	2.2	2.2	2.2	2.2
Basement Floor	RSI	0.0	0.0	0.0	0.0
Slab on Grade	RSI	0.8	1.3	1.7	2.1
Doors	RSI	0.7	0.7	0.7	0.7
Glazing/Windows	RSI	0.36	0.36	0.53	0.53
Average R-2000 Values		**up to 3500**	**5000**	**6500**	**8000**
Number of Homes		14	92	59	1
Ceilings	RSI	6.1	7.6	8.8	10.6
Main Walls	RSI	4.8	5.1	5.4	6.2
Basement Walls:					
Above Grade	RSI	3.3	3.7	4.3	4.6
Below Grade	RSI	3.3	3.5	4.1	4.6
Basement Floor	RSI	1.6	0.6	0.6	0.0
Doors	RSI	0.39	0.43	0.45	0.43
Glazing/Windows	RSI	0.29	0.31	0.3	0.51

APPENDIX B

TABLE 1

AVERAGE ELECTRIC SPACE HEATING CONSUMPTION
(Heating Seasons: Sept. 1985 - Apr. 1986, Sept. 1986 - Apr. 1987)

HOUSE CHARACTERISTICS		CONSUMPTION/HEATING SEASON					
		GigaJoules		MegaJoules/m^3		$\frac{kJ/m^3}{degree\ day}$	
	No.	mean	(s.d.)	mean	(s.d.)	mean	(s.d.)
R-2000 HOME	105	32.2	(13.7)	65.4	(23.5)	14.3	(5.2)
REGION							
Maritimes	22	31.5	(9.5)	60.2	(17.6)	13.5	(4.0)
Quebec	29	33.6	(8.8)	77.3	(19.1)	15.9	(3.9)
Ontario	33	35.8	(17.4)	66.4	(22.1)	15.2	(5.6)
Prairies	10	32.4	(15.5)	65.3	(28.5)	10.7	(4.2)
B.C.	11	18.9	(11.3)	41.2	(25.6)	12.2	(8.0)
CLIMATE ZONE							
0000-3999	15	20.0	(23.5)	51.3	(31.5)	15.2	(9.1)
4000-4999	66	31.7	(9.6)	65.3	(20.3)	14.5	(4.4)
5000-5999	15	31.4	(10.5)	70.4	(24.0)	13.2	(4.7)
>6000	9	44.2	(18.5)	80.9	(20.0)	13.0	(3.0)
VOLUME							
< 500 m^3	60	30.1	(10.4)	71.7	(22.0)	15.7	(4.8)
> 500 m^3	45	35.1	(16.9)	56.8	(23.0)	12.5	(5.3)
OCCUPANCY							
<= 4 occupants	71	31.9	(12.4)	65.1	(21.7)	14.3	(4.9)
> 4 occupants	12	30.3	(15.0)	60.1	(33.1)	12.1	(5.2)
SPACE HEATING EQUIPMENT							
Radiant	64	31.3	(13.2)	67.3	(24.0)	14.4	(4.9)
Forced air	41	33.7	(14.6)	62.2	(22.6)	14.1	(5.8)
WOODBURNING APPLIANCES							
With fireplaces	18	35.8	(17.2)	62.4	(25.0)	14.0	(6.4)
With woodstoves	9	29.6	(8.4)	51.1	(16.8)	11.4	(2.3)
No wood appliance	78	31.7	(13.3)	67.7	(23.4)	14.7	(9.2)
INDOOR AIR TEMPERATURE							
<= 21 °C	54	30.0	(10.8)	60.9	(23.7)	13.6	(5.4)
> 21 °C	47	34.9	(16.5)	70.8	(22.9)	15.1	(5.1)

note: 1kWh = 3.6×10^{-3} GJ, 1 GJ = 1000 MJ = 10^6 kJ

TABLE 2

AVERAGE FOSSIL FUEL SPACE HEATING CONSUMPTION
(Heating Seasons: Sept. 1985 - Apr. 1986, Sept. 1986 - Apr. 1987)

HOUSE CHARACTERISTICS		CONSUMPTION/HEATING SEASON					
		GigaJoules		MegaJoules/m^3		$\frac{kJ/m^3}{degree\ day}$	
	No.	mean	(s.d.)	mean	(s.d.)	mean	(s.d.)
R-2000 HOMES	35	56.2	(19.2)	97.4	(35.1)	19.8	(6.2)
REGION							
Ontario	10	45.3	(20.5)	74.3	(29.3)	18.5	(6.6)
Prairies	22	61.1	(18.1)	109.1	(29.2)	19.2	(5.1)
B.C.	3	56.3	(9.6)	112.1	(61.3)	28.4	(6.9)
CLIMATE ZONE							
0000-3999	8	48.5	(18.7)	74.5	(19.4)	21.6	(6.5)
4000-4999	3	36.0	(20.9)	58.3	(31.3)	14.0	(7.4)
5000-5999	19	61.2	(18.7)	111.8	(33.5)	20.1	(6.1)
>6000	5	61.6	(12.6)	117.1	(25.8)	19.1	(4.3)
VOLUME							
< 500 m^3	11	54.9	(14.9)	121.1	(34.5)	22.6	(5.1)
> 500 m^3	24	56.7	(21.2)	89.5	(31.3)	18.5	(6.3)
OCCUPANCY							
<= 4 occupants	21	57.6	(18.4)	101.0	(35.3)	20.5	(6.1)
> 4 occupants	3	65.5	(25.5)	90.9	(17.7)	19.8	(8.2)
WOODBURNING APPLIANCES							
With fireplaces	16	61.8	(23.5)	99.2	(37.8)	21.1	(6.7)
With woodstoves	3	41.4	(3.9)	79.7	(13.8)	16.4	(3.3)
No wood appliance	16	53.3	(14.1)	103.3	(35.3)	19.1	(5.9)
INDOOR AIR TEMPERATURE							
<= 21 °C	17	60.3	(14.9)	107.1	(32.0)	21.2	(6.1)
> 21 °C	17	51.2	(23.0)	91.1	(38.1)	18.5	(6.3)

note: 1kWh = 3.6×10^{-3} GJ, 1 GJ = 1000 MJ = 10^6 kJ

TABLE 3

COMPARISON OF SPACE HEATING AND TOTAL CONSUMPTION TO THE R-2000 TARGET
(Heating Seasons: Sept. 1985 - Apr. 1986, Sept. 1986 - Apr. 1987)

HOUSE CHARACTERISTICS	RATIO OF CONSUMPTION TO TARGET (Actual/Target)		
	No.	Space mean (s.d.)	Total mean (s.d.)
R-2000 HOMES	133	0.96 (0.33)	1.04 (0.29)
SPACE HEATING FUEL			
Electric	94	0.96 (0.35)	1.03 (0.30)
Fossil Fuel	41	0.96 (0.29)	1.05 (0.22)
REGION			
Maritimes	21	0.93 (0.26)	.98 (0.21)
Quebec	26	1.07 (0.27)	1.16 (0.24)
Ontario	43	0.97 (0.36)	1.06 (0.35)
Prairies	29	0.87 (0.28)	1.02 (0.21)
B.C.	14	0.86 (0.29)	.93 (0.52)
CLIMATE ZONE			
0000-3999	23	1.00 (0.49)	1.01 (0.39)
4000-4999	66	0.95 (0.30)	1.00 (0.27)
5000-5999	31	0.94 (0.31)	1.14 (0.24)
>6000	13	0.93 (0.22)	1.01 (0.21)
VOLUME			
< 500 m^3	68	1.05 (0.31)	1.08 (0.27)
> 500 m^3	65	0.86 (0.33)	1.00 (0.29)
OCCUPANCY			
<= 4 occupants	88	0.96 (0.96)	1.02 (0.24)
> 4 occupants	14	0.82 (0.22)	.95 (0.26)
SPACE HEATING EQUIPMENT			
Radiant	61	0.96 (0.35)	1.03 (0.30)
Forced air	72	0.96 (0.29)	1.04 (0.22)
WOODBURNING APPLIANCES			
With fireplaces	33	0.95 (0.37)	1.04 (0.25)
With woodstoves	12	0.81 (0.14)	0.89 (0.20)
No wood appliance	88	0.98 (0.34)	1.06 (0.30)
INDOOR AIR TEMPERATURE			
<= 21 °C	67	0.94 (0.34)	1.00 (0.23)
> 21 °C	62	0.98 (0.33)	1.07 (0.32)

TABLE 4

COMPARISON OF SPACE HEATING CONSUMPTION WITH THE 1975 NATIONAL BUILDING CODE AND 1983 MEASURES FOR ENERGY CONSERVATION
(Heating Seasons: Sept. 1985 - Apr. 1986, Sept. 1986 - Apr. 87)

HOUSE CHARACTERISTICS	RATIO OF ACTUAL TO 1975 CODE AND 1983 MEASURES (Actual/1975 Code or 1983 Measures)		
	No.	1975 Code mean (s.d.)	1983 Measures mean (s.d.)
R-2000 HOMES	139	0.29 (0.09)	0.62 (0.22)
FUEL TYPE			
Electric	105	0.29 (0.10)	0.62 (0.23)
Fossil Fuel	34	0.30 (0.08)	0.60 (0.17)
REGION			
Maritimes	22	0.26 (0.06)	0.57 (0.15)
Quebec	29	0.31 (0.07)	0.67 (0.17)
Ontario	42	0.28 (0.11)	0.65 (0.23)
Prairies	32	0.28 (0.09)	0.55 (0.17)
B.C.	14	0.26 (0.11)	0.62 (0.38)
CLIMATE ZONE			
0000-3999	23	0.29 (0.14)	0.67 (0.36)
4000-4999	68	0.28 (0.08)	0.61 (0.18)
5000-5999	34	0.29 (0.09)	0.60 (0.20)
>6000	14	0.30 (0.06)	0.60 (0.13)
VOLUME			
< 500 m^3	71	0.29 (0.08)	0.67 (0.22)
> 500 m^3	68	0.28 (0.10)	0.57 (0.21)
OCCUPANCY			
<= 4 occupants	92	0.28(0.08)	0.61 (0.22)
> 4 occupants	15	0.28 (0.09)	0.57 (0.22)
SPACE HEATING EQUIPMENT			
Radiant	64	0.28 (0.09)	0.62 (0.23)
Forced air	75	0.29 (0.10)	0.62 (0.21)
WOODBURNING APPLIANCES			
With fireplaces	33	0.30 (0.10)	0.63 (0.24)
With woodstoves	12	0.23 (0.06)	0.49 (0.10)
No wood appliance	94	0.29 (0.09)	0.63 (0.22)
INDOOR AIR TEMPERATURE			
<= 21 °C	71	0.28 (0.08)	0.61 (0.22)
> 21 °C	67	0.29 (0.10)	0.59 (0.21)

TABLE 5

AVERAGE TOTAL ENERGY CONSUMPTION - ELECTRIC SPACE HEATING
(May 1985 - April 1986, May 1986 - April 1987)

HOUSE CHARACTERISTICS		CONSUMPTION/YEAR			
		GigaJoules		MegaJoules/m^3	$\frac{kJ/m^3}{degree\ day}$
	No.	mean	(s.d.)	mean (s.d.)	mean (s.d.)
R-2000 HOMES	94	74.8	(21.7)	152.5 (42.8)	33.7 (10.0)
REGION					
Maritimes	21	73.0	(15.5)	138.1 (32.6)	30.7 (6.8)
Quebec	25	74.6	(13.7)	176.1 (33.0)	36.2 (6.6)
Ontario	30	83.6	(26.5)	154.4 (44.4)	35.7 (10.2)
Prairies	8	76.6	(21.3)	151.9 (34.0)	25.3 (4.4)
B.C.	10	51.7	(18.4)	118.6 (55.8)	34.4 (18.7)
CLIMATE ZONE					
0000-3999	13	67.6	(23.8)	137.9 (47.7)	40.8 (14.7)
4000-4999	61	72.1	(19.4)	145.6 (38.1)	32.5 (8.7)
5000-5999	13	84.8	(18.6)	192.7 (41.9)	35.9 (8.5)
>6000	7	94.0	(29.0)	165.4 (35.2)	26.4 (5.1)
VOLUME					
< 500 m^3	51	68.0	(19.1)	164.5 (44.0)	36.4 (10.7)
> 500 m^3	43	83.0	(21.9)	138.3 (37.0)	30.5 (8.2)
OCCUPANCY					
<= 4 occupants	61	73.8	(21.5)	150.4 (37.3)	33.6 (9.5)
> 4 occupants	12	77.2	(23.1)	150.0 (59.8)	30.8 (10.7)
SPACE HEATING EQUIPMENT					
Radiant	58	71.6	(21.0)	155.7 (45.5)	34.0 (4.9)
Forced Air	36	80.1	(22.0)	147.3 (38.1)	33.3 (9.6)
INDOOR AIR TEMPERATURE					
<= 21 °C	47	70.5	(18.0)	142.8 (41.1)	32.8 (11.1)
> 21 °C	43	80.5	(23.8)	164.5 (41.3)	34.8 (8.5)

note: 1kWh = 3.6×10^{-3} GJ, 1 GJ = 1000 MJ = 10^6 kJ

TABLE 6

AVERAGE TOTAL ENERGY CONSUMPTION - FOSSIL FUEL HEAT
(May 1985 - April 1986, May 1986 - April 1987)

HOUSE CHARACTERISTICS		CONSUMPTION/YEAR					
		GigaJoules		MegaJoules/m^3		$\frac{kJ/m^3}{degree\ day}$	
	No.	mean	(s.d.)	mean	(s.d.)	mean	(s.d.)
R-2000 HOMES	41	111.2	(31.8)	198.8	(72.1)	41.2	(17.8)
REGION							
Maritimes	2	60.6	(58.7)	113.1	(107.5)	24.5	(23.3)
Ontario	10	99.0	(32.3)	172.0	(69.5)	41.6	(13.4)
Prairies	24	122.1	(27.7)	212.8	(56.7)	37.5	(9.3)
B.C.	5	103.7	(8.1)	219.7	(111.7)	64.4	(35.0)
CLIMATE ZONE							
0000-3999	10	100.0	(19.2)	177.1	(78.6)	53.5	(27.4)
4000-4999	4	68.6	(44.7)	115.6	(66.0)	26.5	(14.8)
5000-5999	21	120.5	(29.1)	210.1	(59.6)	38.2	(10.5)
>6000	3	125.9	(22.8)	258.9	(57.6)	40.9	(9.7)
VOLUME							
< 500 m^3	10	115.8	(34.5)	270.2	(79.0)	55.7	(26.4)
> 500 m^3	31	109.8	(31.4)	175.8	(52.9)	36.5	(10.9)
OCCUPANCY							
<= 4 occupants	27	108.6	(35.7)	191.2	(83.0)	40.9	(20.9)
> 4 occupants	3	138.2	(8.7)	203.6	(40.7)	42.1	(4.8)
INDOOR AIR TEMPERATURE							
<= 21 °C	23	115.5	(25.7)	208.5	(71.8)	44.5	(20.9)
> 21 °C	15	111.1	(34.8)	195.5	(68.4)	39.1	(10.6)

note: 1kWh = 3.6×10^{-3} GJ, 1 GJ = 1000 MJ = 106 kJ

TABLE 7

COMPARISON OF TOTAL ANNUAL CONSUMPTION TO THE R-2000 TARGET
(May 1985 - April 1986, May 1986 - April 1987)

HOUSE CHARACTERISTICS	RATIO OF CONSUMPTION TO TARGET (Actual/Target)	
	No.	mean (s.d.)
R-2000 HOMES	135	1.02 (0.26)
SPACE HEATING FUEL TYPE		
Electric	94	1.01 (0.26)
Fossil fuel	41	1.02 (0.26)
REGION		
Maritimes	23	0.94 (0.25)
Quebec	25	1.07 (0.18)
Ontario	40	1.09 (0.29)
Prairies	32	0.99 (0.21)
B.C.	15	0.90 (0.30)
CLIMATE ZONE		
0000-3999	23	1.04 (0.28)
4000-4999	65	0.97 (0.27)
5000-5999	34	1.08 (0.22)
>6000	13	1.04 (0.21)
VOLUME		
< 500 m^3	61	1.02 (0.27)
> 500 m^3	74	1.01 (0.25)
OCCUPANCY		
<= 4 occupants	88	0.99 (0.25)
> 4 occupants	15	1.04 (0.29)
SPACE HEATING EQUIPMENT		
Radiant	59	0.99 (0.25)
Forced air	76	1.03 (0.26)
WOODBURNING APPLIANCES		
With fireplaces	36	1.12 (0.21)
With woodstoves	16	0.92 (0.28)
No appliance	83	0.99 (0.26)
INDOOR AIR TEMPERATURE		
<= 21 °C	70	1.00 (0.23)
> 21 °C	58	1.06 (0.26)

TABLE 8

COMPARISON OF TOTAL ENERGY CONSUMPTION WITH THE 1975 NATIONAL BUILDING CODE AND 1983 MEASURES FOR ENERGY CONSERVATION
(May 1985 - April 1986, May 1986 - April 1987)

HOUSE CHARACTERISTICS	RATIO OF ACTUAL TO 1975 CODE AND 1983 MEASURES (Actual/1975 Code or 1983 Measures)		
	No.	1975 Code mean (s.d.)	1983 Measures mean (s.d.)
R-2000 HOMES	133	0.48 (0.14)	0.77 (0.19)
SPACE HEATING FUEL TYPE			
Electric	93	0.49 (0.14)	0.78 (0.20)
Fossil Fuel	40	0.46 (0.13)	0.74 (0.18)
REGION			
Maritimes	22	0.46 (0.12)	0.73 (0.15)
Quebec	25	0.52 (0.10)	0.82 (0.15)
Ontario	40	0.51 (0.17)	0.83 (0.24)
Prairies	32	0.45 (0.11)	0.71 (0.15)
B.C.	14	0.47 (0.14)	0.70 (0.19)
CLIMATE ZONE			
0000-3999	23	0.50 (0.15)	0.79 (0.22)
4000-4999	65	0.47 (0.14)	0.76 (0.20)
5000-5999	32	0.49 (0.14)	0.78 (0.19)
>6000	13	0.49 (0.09)	0.77 (0.13)
VOLUME			
< 500 m^3	60	0.50 (0.13)	0.78 (0.19)
> 500 m^3	73	0.48 (0.14)	0.76 (0.19)
OCCUPANCY			
<= 4 occupants	86	0.47 (0.13)	0.75 (0.18)
> 4 occupants	15	0.53 (0.12)	0.81 (0.21)
SPACE HEATING EQUIPMENT			
Radiant	58	0.48 (0.11)	0.76 (0.18)
Forced air	75	0.49 (0.15)	0.79 (0.20)
WOODBURNING APPLIANCES			
With fireplaces	36	0.52 (0.15)	0.82 (0.19)
With woodstoves	15	0.42 (0.12)	0.69 (0.19)
No appliances	82	0.48 (0.13)	0.76 (0.19)
INDOOR AIR TEMPERATURE			
<= 21 °C	69	0.48 (0.12)	0.76 (0.17)
> 21 °C	58	0.50 (0.15)	0.79 (0.21)

TABLE 9

AVERAGE ELECTRIC WATER HEATING CONSUMPTION
(May 1985 - April 1986, May 1986 - April 1987)

HOUSE CHARACTERISTICS		CONSUMPTION/YEAR			
		GJ/year		kWh/day	
	No.	mean	(s.d.)	mean	(s.d.)
R-2000 HOMES	102	16.4	(7.1)	12.5	(5.4)
REGION					
Maritimes	21	15.4	(6.2)	11.7	(4.7)
Quebec	25	16.6	(6.8)	12.6	(5.2)
Ontario	38	17.8	(6.9)	13.5	(5.3)
Prairies	8	18.4	(9.6)	14.0	(7.3)
B.C.	10	11.0	(5.8)	8.4	(4.4)
CLIMATE ZONE					
0000-3999	18	14.2	(8.0)	10.8	(6.1)
4000-4999	63	15.9	(6.4)	12.1	(4.8)
5000-5999	15	20.6	(8.1)	15.7	(6.2)
>6000	6	17.3	(5.3)	13.2	(4.0)
VOLUME					
< 500 m^3	52	16.1	(7.0)	12.2	(5.4)
> 500 m^3	50	16.7	(7.1)	12.7	(5.4)
OCCUPANCY					
<= 4 occupants	65	15.5	(6.7)	11.8	(5.1)
> 4 occupants	13	16.2	(8.8)	12.3	(6.7)

note: 1 kWh = 3.6×10^{-3} GJ

TABLE 10

AVERAGE FOSSIL FUEL WATER HEATING CONSUMPTION
(May 1985 - April 1986, May 1986 - April 1987)

HOUSE CHARACTERISTICS		CONSUMPTION/YEAR	
		GJ/year	kWh/day
	No.	mean (s.d.)	mean (s.d.)
R-2000 HOMES	24	30.0 (12.3)	22.8 (9.4)
REGION			
Maritimes	1	26.8 (0.0)	20.4 (0.0)
Ontario	2	26.6 (24.8)	20.3 (18.9)
Prairies	17	32.9 (11.9)	25.0 (9.0)
B.C.	4	20.1 (4.0)	15.3 (3.1)
CLIMATE ZONE			
0000-3999	4	17.5 (6.9)	13.3 (5.2)
4000-4999	1	26.8 (0.0)	20.4 (0.0)
5000-5999	13	33.1 (11.6)	25.2 (8.8)
>6000	6	32.1 (13.7)	24.5 (10.4)
VOLUME			
< 500 m^3	6	36.7 (7.5)	27.9 (8.8)
> 500 m^3	18	27.8 (12.0)	21.1 (9.2)
OCCUPANCY			
<= 4 occupants	17	30.6 (12.8)	23.3 (9.8)
> 4 occupants	2	20.0 (15.4)	15.2 (11.8)

note: 1kWh = 3.6×10^{-3} GJ

TABLE 11

COMPARISON OF WATER HEATING CONSUMPTION TO THE R-2000 TARGET
(May 1985 - April 1986, May 1986 - April 1987)

HOUSE CHARACTERISTICS	RATIO OF ACTUAL TO TARGET (Actual/Target)	
	No.	mean (s.d.)
R-2000 HOMES	126	0.89 (0.38)
WATER HEATING FUEL		
Electric	102	0.89 (0.38)
Fossil Fuel	24	0.88 (0.35)
REGION		
Maritimes	22	0.84 (0.33)
Quebec	25	0.90 (0.37)
Ontario	40	0.96 (0.39)
Prairies	25	0.99 (0.39)
B.C.	14	0.61 (0.27)
CLIMATE ZONE		
0000-3999	22	0.73 (0.41)
4000-4999	64	0.87 (0.34)
5000-5999	32	1.05 (0.40)
>6000	12	0.97 (0.29)
VOLUME		
< 500 m^3	58	0.90 (0.38)
> 500 m^3	68	0.89 (0.37)
OCCUPANCY		
<= 4 occupants	82	0.86 (0.36)
> 4 occupants	15	0.84 (0.47)

TABLE 12

LIGHTS AND APPLIANCES CONSUMPTION
(May 1985 - April 1986, May 1986 - April 1987)

HOUSE CHARACTERISTICS		CONSUMPTION/YEAR	
		GJ/year	kWh/day
	No.	mean (s.d.)	mean (s.d.)
R-2000 HOMES	103	29.5 (12.2)	22.4 (9.3)
REGION			
Maritimes	20	26.4 (9.5)	20.1 (7.3)
Quebec	21	23.5 (9.4)	17.9 (7.1)
Ontario	33	32.7 (13.1)	24.9 (10.0)
Prairies	17	39.0 (10.7)	29.7 (8.1)
B.C.	12	22.5 (9.2)	17.2 (7.0)
CLIMATE ZONE			
0000-3999	18	30.2 (14.2)	23.0 (10.8)
4000-4999	56	25.7 (9.3)	19.6 (7.1)
5000-5999	19	38.2 (14.1)	29.0 (10.7)
>6000	10	35.0 (9.4)	26.6 (7.1)
VOLUME			
< 500 m^3	48	24.7 (9.7)	18.8 (7.3)
> 500 m^3	55	33.6 (12.6)	25.6 (9.6)
OCCUPANCY			
<= 4 occupants	69	27.7 (11.8)	21.1 (9.0)
> 4 occupants	12	39.5 (16.5)	30.1 (12.5)
ENERGY CONSUMING APPLIANCES			
None	54	27.9 (9.4)	21.2 (7.2)
One	35	29.6 (11.7)	22.5 (8.9)
Two or more	14	35.4 (19.6)	26.9 (14.9)
SPACE HEATING FUEL TYPE			
Electric	80	28.0 (11.8)	21.3 (9.0)
Fossil Fuel	23	34.5 (12.3)	26.2 (9.3)
SPACE HEATING EQUIPMENT TYPE			
Radiant	49	25.1 (9.6)	19.1 (7.3)
Forced Air	54	33.7 (12.6)	25.7 (9.6)

note: 1 kWh = 3.6×10^{-3} GJ

TABLE 13

COMPARISON OF LIGHTS AND APPLIANCES CONSUMPTION WITH R-2000 ASSUMPTIONS
(May 1985 - April 1986, May 1986 - April 1987)

HOUSE CHARACTERISTICS	RATIO OF ACTUAL TO ASSUMPTION (Actual/Assumption)	
	No.	mean (s.d.)
R-2000 HOMES	103	1.40 (0.58)
REGION		
Maritimes	20	1.26 (0.45)
Quebec	21	1.12 (0.45)
Ontario	33	1.56 (0.62)
Prairies	17	1.85 (0.51)
B.C.	12	1.07 (0.44)
CLIMATE ZONE		
0000-3999	18	1.38 (0.67)
4000-4999	56	1.22 (0.44)
5000-5999	19	1.81 (0.67)
>6000	10	1.67 (0.45)
VOLUME		
< 500 m^3	48	1.18 (0.46)
> 500 m^3	55	1.60 (0.60)
OCCUPANCY		
<= 4 occupants	69	1.32 (0.56)
> 4 occupants	12	1.87 (0.78)
ENERGY CONSUMING APPLIANCES		
None	54	1.33 (0.45)
One	35	1.41 (0.56)
Two or more	14	1.68 (0.93)
SPACE HEATING FUEL TYPE		
Electric	80	1.33 (0.56)
Fossil Fuel	23	1.64 (0.58)
SPACE HEATING EQUIPMENT TYPE		
Radiant	49	1.19 (0.45)
Forced Air	54	1.60 (0.60)

APPENDIX C

REGRESSION EQUATIONS

The explanatory variables used in the equations are explained below.

DD - Celsius degree days
V - Volume in m^3
T - Temperature in Fahrenheit
WS - Wood stove dummy variable
AR - Ratio of supply to exhaust air from the HRV
O - Number of occupants
AP - Number of energy consuming appliances

ELECTRIC SPACE HEATING CONSUMPTION REGRESSION EQUATIONS

Space Heating - Climate, Volume and Temperature

Space Heating Consumption (kWh/day) = .008(DD) + .053(V) + 1.055(T) - 94.356

d.f. = 48 t = 3.78 t = 3.97 t = 2.12

Adjusted R^2 = .42 Durbin Watson statistic = 1.90

Space Heating - Climate, Volume, Temperature and Wood Stove

Space Heating Consumption (kWh/day) = .008(DD) + .058(V) + .965(T) - 7.043(WS) - 88.784

d.f. = 47 t = 3.68 t = 4.20 t = 1.93 t = -1.29

Adjusted R^2 = .43 Durbin Watson statistic = 1.97

Space Heating - Climate, Volume, Temperature, Wood Stove and Exhaust to Supply Air Ratio

Space Heating Consumption (kWh/day) = .008(DD) + .055(V) + 1.038(T) - 14.942(AR) - 6.686(WS) - 78.189

d.f. = 46 t = 3.85 t = 3.92 t = 2.09 t = -1.38 t = -1.23

Adjusted R^2 = .44 Durbin Watson statistic = 1.87

Total Energy over Space Heating Season - Climate, Volume and Temperature

Total Energy Consumption = .012(DD) + .069(V) + 1.542(T) - 122.790
Space Heating Season
(kWh/day)

d.f. = 48 t = 4.38 t = 3.96 t = 2.35

Adjusted R^2 = .46 Durbin Watson statistic = 1.99

Total Energy over Space Heating Season - Climate, Volume, Temperature and Wood Stove

Total Energy Consumption = .012(DD) + .084(V) + 1.303(T) - 18.736(WS) - 107.965
Space Heating Season
(kWh/day)

d.f. = 47 t = 4.41 t = 4.86 t = 2.10 t = -2.76

Adjusted R^2 = .53 Durbin Watson statistic = 2.26

Total Energy over Space Heating Season - Climate, Volume, Temperature, Exhaust to Supply Air Ratio and Wood Stove

Total Energy Consumption = .012(DD) + .078(V) + 1.410(T) - 21.951(AR) - 18.211(WS) - 92.400
Space Heating Season
(kWh/day)

d.f. = 46 t = 4.65 t = 4.57 t = 2.30 t = -1.64 t = -2.73

Adjusted R^2 = .54 Durbin Watson statistic = 2.11

TOTAL ENERGY CONSUMPTION REGRESSION EQUATIONS

Total Energy - Climate, Volume and Temperature

Total Energy Consumption = .008(DD) + .053(V) + 1.388(T) - 102.530
(kWh/day)

d.f. = 48 t = 3.89 t = 4.29 t = 3.00

Adjusted R^2 = .48 Durbin Watson statistic = 2.24

Total Energy - Climate, Volume, Temperature and Wood Stove

Total Energy Consumption = .007(DD) + .061(V) + 1.259(T) - 10.098(WS) - 95.54
(kWh/day)

d.f. = 47 t = 3.82 t = 4.84 t = 2.78 t = -2.04

Adjusted R^2 = .51 Durbin Watson statistic = 2.04

Total Energy - Climate, Volume, Temperature, Exhaust to Supply Air Ratio and Wood Stove

Total Energy Consumption = .008(DD) + .058(V) + 1.324(T) - 13.089(AR) - 9.785(WS) - 85.260
(kWh/day)

d.f. = 46 t = 4.65 t = 4.57 t = 2.30 t = -1.64 t = -2.73

Adjusted R^2 = .52 Durbin Watson statistic = 2.08

ELECTRIC WATER HEATING CONSUMPTION REGRESSION EQUATION

Water Heating - Climate, Number of Occupants and Temperature

Water Heating Consumption = .002(DD) + .619(O) + .217(T) - 14.00
(kWh/day)

d.f. = 64 t = 2.55 t = 1.24 t = 1.34

Adjusted R^2 = .13 Durbin Watson statistic = .37

LIGHTS & APPLIANCES CONSUMPTION REGRESSION EQUATION

Lights & Appliances - Climate, Volume, Number of Occupants and Energy Consuming Appliances

Lights & Appliances Consumption = .003(DD) + .012(V) + .448(O) + 2.243(AP) - 4.434
(kWh/day)

d.f. = 76 t = 2.98 t = 1.63 t = 2.11 t = 1.26

Adjusted R^2 = .35 Durbin Watson statistic = 1.48